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USSR Report

MATERIALS SCIENCE AND METALLURGY

No. 71

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DEVELOPMENT OF SOVIET ALUMINUM INDUSTRY HIGHLIGHTED

Budapest MAGYAR ALUMINIUM in Hungarian Vol 16, No 12, Dec 79 pp 353-359

[Text of paper presented by N. A. Kaluzhskiy, director of the All-Union Aluminum-Magnesium and Electrode Industry Scientific Research and Design Institute, USSR, at the Aluminum-Industry Scientific and Technical Conference, held 25-26 September 1979 in Szekesfehervar, Hungary]

[Text] The aluminum industry is one of the fastest-growing nonferrous metallurgical industry branches in the USSR.The growth rate of the Soviet aluminum-metallurgical industry exceeds that of the U.S., those of the capitalist countries, and those of the developing countries all added together (Fig. 1).

Twenty-seven enterprises make up the aluminum industry. They produce 158 different products, and the value of the annual output is 3 billion rubles. Manufacture of the entire Soviet production of crude aluminum, silicon, alumina, potassium carbonate, crude gallium, and white corundum, and much of the fluorine-containing salt production, as well as considerable amounts of soda ash, cement, mineral fertilizers, and other substances is carried out in these enterprises. More than half of the total production represents high-quality products.

In addition to achieving intensive quantitative growth, we can also report major achievements in the area of scientific and technical development. The scientists and experts of the All-Union Aluminum-Magnesium Industry Institute (VAMI), in cooperation with the enterprises, developed more than 140 new technological processes, individual pieces of equipment, and mechanization and automation devices during the last 10 years. During the same period, they registered 993 patents and developed 130 technical solutions patented abroad. Licenses for the know-how of the inventions developed at the Institute have been purchased in 12 countries, including the U.S., Japan, and Canada.

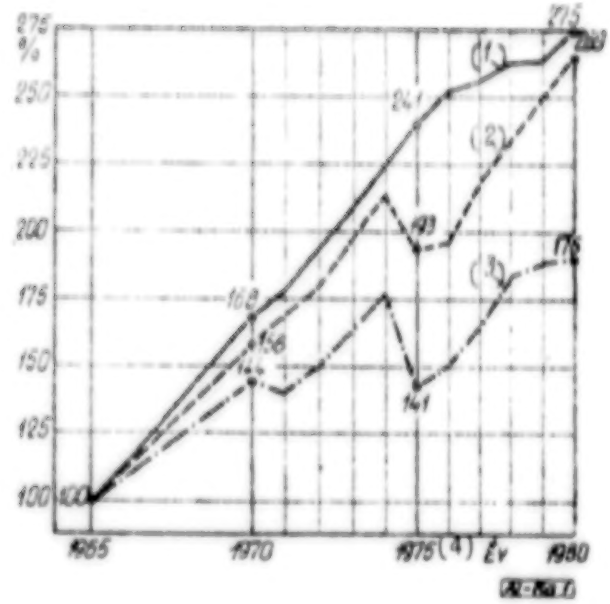

Fig. 1. Growth rate of metallurgical aluminum production in the USSR, in the U.S., and in capitalist and developing countries between 1965 and 1980

Key: 1. USSR
2. Capitalist and developing countries
3. United States
4. Year

The major technical and scientific trends characterizing the modern Soviet aluminum industry include the following:

- Broad industrial processing of new aluminum raw materials and the complex utilization of the products;

- Further concentration of production and specialization of manufacture, wider product assortment and improved quality;

- Development and implementation of new, highly effective technological processes, increased production of manufacturing systems and individual pieces of equipment;

- Mechanization and automation of the productive processes and improved productivity;

- Further improvement in the working conditions and upgrading of the health level of the environment.

Manufacture of Alumina and Chemical Products

Unlike other countries, the USSR uses both bauxite and non-bauxite raw materials for the manufacture of alumina.

Soviet scientists and experts were the first to develop the technology for the complex processing of nephelite. The process yields alumina, soda ash, potassium carbonate, and cement. At the present time, three enterprises process nepheline raw material. The amount of alumina manufactured from nepheline increased 4.7 fold between 1968 and 1978, the amount of soda ash and potassium carbonate increased 4.1 fold, and the amount of cement increased 1.8 fold during the same period.

[Photo not reproduced]

Flotational nepheline concentrate originating from Kolsk, containing 29 percent Al_2O_3, 13 percent Na_2O, and 7 percent K_2O, is processed at the Alumina Factory of Pikalevsk. By introducing a modern technology, producing little waste, this enterprise produces alumina at the lowest cost in the country.

Nepheline ore (containing 27 percent Al_2O_3 and 13 percent $Na_2O + K_2O$) is processed by a complex technology into alumina and other products at one of the world's largest alumina factories, operated within the Achinsk alumina combine. Sintering of the nepheline-limestone mixture is carried out at the combine in a 185-m-long rotary furnace having a diameter of 5 meters (Fig. 2). The output of the furnace is 100 tons per hour. This plant also operates high-output crushers and other chemical equipment. Production capacity is continuously increased in the combine, and the engineering and economic indicators improve from year to year.

Regeneration-type alkali processing of the alunite ore was introduced for the first time anywhere in the aluminum factory located in Kirovabad. The ore, containing 51 percent alunite, is processed to yield alumina, sulfuric acid, and high-quality potassiun sulfate.

Major technical innovations were also introduced in the field of bauxite processing. Depending on the quality of the bauxite, the Soviet aluminum industry uses one of four different methods of processing:

- The generally known Bayer-type hydrochemical method;

- Sintering a mixture of bauxite, soda ash, and limestone followed by the hydrochemical processing of the sintering product (sinter method);

- Parallel combination of the Bayer and sinter methods;

Table 1. Comparative parameters for the processing of various types of aluminum raw material

Designation	Unit	Processing of high-quality bauxites (module 10-15) by the Bayer method	Processing of low-quality bauxites (Si module 3.5-4) by series Bayer and sinter method	Processing of nepheline ore: Concentrate 29% Al_2O_3	Processing of nepheline ore: Ore 27% Al_2O_3	Processing of alunite ore (51% aluminum)
	I. Manufacture of finished product					
Alumina	kg	1000	1000	1000	1000	1000
Calcined soda ash (100% Na_2CO_3)	kg		-	690	500	-
Potassium carbonate (100% K_2CO_3)	kg	-	-	320	90	-
Potassium sulfate (100% K_2SO_4)	kg	-	-	-	23	960
Sulfuric acid (100% H_2SO_4)	kg	-	-	-	-	2070
Cement	tons	-	-	7.6	8.9	-
	II. Investment and operating expenses for total product worth 1000 rubles related to the Bayer-type bauxite processing					
Investment costs	%	100	130	145	155	115
Operating costs	%	100	150	120	125	145

- Series combination of the Bayer and sinter methods. This method is used in the Pavlodav aluminum factory, where bauxite from Kazakhstan, containing 44 percent Al_2O_3 and 12 percent SiO_2, is processed.

Since a wide range of engineering and technological methods is available, both high- and low-grade bauxite can be efficiently processed.

Table 1 summarizes the comparative parameters characterizing the processing of the various aluminum raw materials.

Industrial methods for the extraction of valuable microimpurities (gallium and vanadium pentoxide) from the aluminum-containing ores were developed and implemented. This improves the complex processing of the raw material. Production of alumina types for various non-metallurgical end uses, such as uses in ceramic, radio-electronic, petrochemical, and other industries, has been set up.

The experiences gained by the USSR with the complex processing of various aluminum raw materials are of interest to many countries which lack deposits of high-quality bauxite.

The long-range development program of the Soviet aluminum industry provides for major production increase for alumina, to be accomplished by the startup of the alumina factory in Nikolaevsk and by the expansion of the productive capacity of several other factories. In the process, there will also be a production increase of soda ash, potassium carbonate, cement, mineral fertilizer, and other products.

Aluminum Metallurgy and Manufacture of Anode Material

The Soviet aluminum industry leads all other countries of the world insofar as concentration of production and the average output of the aluminum-electrolysis equipment is concerned.The aluminum factories in Bratsk, Krasnoyarsk, Novokuznetsk, and Irkutsk are among the ten largest anywhere; in addition, other large factories are under construction (for example the factories in Tadzhisk and Sayonsk, where aluminum smelters are being built).

The industry uses three types of aluminum-electrolysis equipment: self-baking anode type equipment with overhead electricity supply, self-baking anode type equipment with lateral electricity supply, and block-anode type equipment.

The aluminum factories in Siberia use high-efficiency electrolysis equipment in their most modern electrolysis factories. This equipment operates with a current of up to 159 kA, feature a current utilization of 86 to 86.5 percent, and a specific energy consumption of 15,550 to 15,750 kWhr/ton (d.c.).

This equipment is some of the best to be found anywhere in the world; the bus system of the electrolysis equipment is licensed by Japanese and Canadian enterprises. Modernization of earlier electrolysis equipment with overhead electricity supply is made in line with the above design.

The covered electrolysis equipment developed at the "VAMI" and approved for series manufacture uses block anodes and operates at a current of 160 kA. Production with electrolysis equipment of this design in the new electrolysis plant of the aluminum-goods factory in Tadzhisk is 1,130 kg/day, and features the lowest d.c. power consumption in the country: 14,500 kWhr/ton.

As a result of the startup of more modern electrolysis equipment and the technical developments in aluminum manufacture, the average current level in electrolysis systems increased by an average of 20 percent in the industry sector, while there was more than doubling insofar as the block-anode electrolysis systems are concerned (see Fig. 3) between 1968 and 1978.

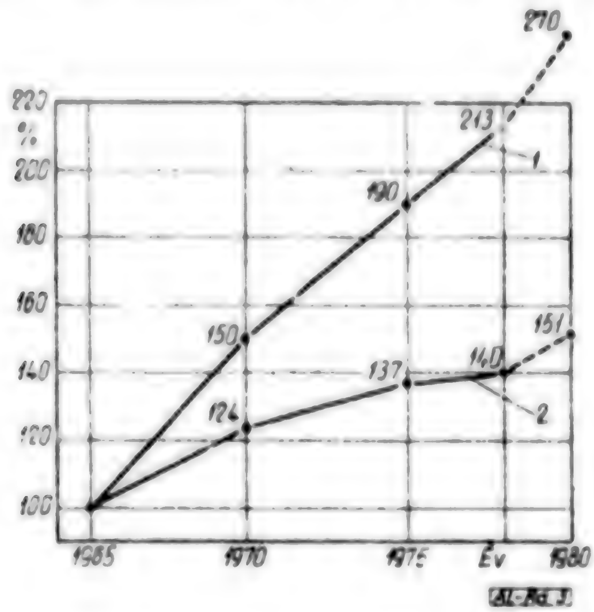

Fig. 3. Average increase in the current level of aluminum-electrolysis tanks in the Soviet Union between 1965 and 1980.

Key: 1. Block-anode tanks
2. Industry average
3. Year

Considering the fact that the block-anode electrolysis equipment is superior to the self-baking anode equipment in technical and health terms, we decided to use block-anode electrolysis equipment in our new aluminum factories and as replacement for obsolescent electrolysis systems, in spite of the fact that such equipment requires higher specific investment expenditures.

A 175 kA block-anode electrolysis unit was developed at the "VAMI" for the new electrolysis systems. In this unit, the alumina is fed automatically. Industrial trials of a very large 260 kA block-anode electrolysis system are in progress (see Figs. 4 and 5). The new electrolysis systems will be automatically controlled. The control will be carried out by a computer system called "Elektrolie."

[Photo not reproduced]

Since the demand for pure aluminum increases all the time, we developed in one of our factories a manufacturing technology with which pure aluminum is produced in 70 kA refining electrolyzers, which are the largest of their kind anywhere in the world. We also established the method for manufacturing very-high purity (up to 99,9999 percent) aluminum by means of zone melting for meeting the needs of the electronics industry.

Complex mechanization and automation of the electrolysis factories permits an increase of the mechanization ratio of the work to 85-90 percent, and thus a reduction in the physical stresses imposed on the workers.

Electrolyte aluminum production based on block-anode electrolysis equipment must be combined with large-scale block-anode manufacture, where the "anode stumps" are repeatedly recycled. Along these lines, the construction of a new, modern block-anode plant (anode dimensions 1,400 by 700 by 600 mm) is almost completed in the aluminum factory at Tadzhisk. It will have an annual capacity of 260,000 tons. High-output equipment purchased in France will be used in the new plant.

Eighty-five percent of the aluminum-industry production capacity is equipped with two-stage gas-filtration equipment and devices for the regeneration of fluorine compounds. More than 93 percent of the harmful contaminants are recovered in the new heated-anode electrolysis systems.

Sensible utilization of the water resources is implemented primarily by entirely stopping the release of industrial wastewater. The aluminum factories cover 75 percent of their water needs with purified wastewater, and this percentage increases every year.

The major tasks concerning the further reduction of harmful releases into the atmosphere and prevention of the contamination of the waters include the following:

- Implementation of complex technological and technical-administrative measures aimed at the reduction of the total amount of contaminants released;

- Widespread introduction of block-anode electrolysis systems, and conversion of the existing electrolysis systems to lateral electricity supply, simultaneous conversion to the use of effective gas-purification equipment, plus modernization of the existing industrial gas-purifier systems and equipment;

- Completion of the work concerning the standardization of harmful ingredients, and setting up the maximum permissible concentrations for each plant and for each contaminant;

- Conversion of all aluminum-industry plants to operation without any wastewater discharge.

International Cooperation

Implementing the resolutions promulgated at the 24th and 25th Congresses of the Communist Party of the USSR, we significantly broadened and strengthened international cooperation in the aluminum industry.

We established technical-scientific or economic relations with 80 enterprises in 35 countries. Based on developments and plans prepared by the VAMI, or with Soviet assistance, several aluminum and alumina factories were set up, for example in Egypt, India, Turkey, and Yugoslavia. Plans call for the construction of aluminum and alumina factories in Cuba, Algeria, Bulgaria, and other countries.

Very important engineering modernization was carried out in the anode-mass producing plant sectors also (use of pitch and inhibitor additives with high melting point, optimum dry-matter composition, use of rotary furnaces utilizing waste heat for petroleum-coke heating, and so forth).

Manufacture of aluminum by electrolysis of cryolite-alumina melts consumes a great deal of electricity, requires major investment and operating expenditures, and contaminates the atmosphere with toxic gases which contain fluorine, in spite of the fact that the method has been much improved by now. Thus, the "VAMI," in cooperation with other research institutions, investigates the development of novel methods for manufacturing aluminum, such as:

- Manufacture of aluminum by the electrolysis of aluminum chloride;

- Two-step aluminum manufacture; in the first step the aluminum ore is electro-thermally reduced so that an aluminum-silicon-iron-titanium primary alloy forms; in the second step the primary alloy is catalytically distilled and the aluminum is extracted with sub-halide compounds.

A unique plant operates at the aluminum factory in Dnepropetrovsk for the manufacture of aluminum-silicon alloys. There, direct reduction of aluminum silicates is carried out. The ore is reduced in 16 thermal furnaces operating at 500 kA.

Casting and Fabricating Aluminum and Aluminum Alloys

Technical development in the field of aluminum and aluminum-alloy casting and fabricating moves toward expansion of the finished-product assortment, improvement of the quality of the aluminum products intended for further processing, and improving the individual production of the melting-casting and casting-rolling equipment.

Production of special and non-remelted product types increased more than three-fold during the last 10 years; specifically, that of rolled products increased approximately 5.5 fold, that of ingots 5.2 fold, and that of casting alloys and powder-metallurgical products 5.5 fold. Manufacture of large-size blocks and T-fittings, casting alloys for the automobile factories in Volga and Kama, special powder-metallurgical items, and other product types has been realized.

Effective 1 January 1975, the Soviet aluminum industry switched to new GOST standards in the production of crude aluminum. The provisions of these new standards correspond to the provisions of the international standards.

In the casting shops of the aluminum factories, 25-40 ton annealing ovens and semi-automatic casting equipment are widely used. There are also many aggregates for simultaneous casting and rolling, casting conveyors suitable for block casting with automated block depositors (output: six tons per hour), and other equipment.

The following may be expected in the near future:

- Further increase in the production volume of non-remelted and specialized product types, and increased production of casting-type aluminum alloys;

- Introduction of high-output casting-melting equipment (annealing ovens with a capacity of 70 tons, semi-automatic block-casting units producing 10-15 tons per hour, and so forth) in newly constructed factories and in updated factories;

- Gradual introduction of progressive technological processes and wide utilization of these processes (continuous aluminum purification; removal of metallic ingredients, gas occlusions, and oxides; transportation of the metal by means of magneto-dynamic methods) with the aim of improving the quality of the product;

- Setting up the production of foil, strip, and preserve-industry packaging products, as well as disks and metal-insert plastic products by establishing the production of the rolled goods required for them by means of simultaneous casting and rolling;

- Introduction of the industrial-scale manufacture of metal granules from aluminum alloys and the conversion of the granules into further semi-finished goods, and increase in the manufacturing capacity of novel metal powders.

Protection of the Environment

Protection of the environment is an important consideration in the complex technical development plan of the aluminum industry. The amount of air contaminants released into the atmosphere decreases every year. More than

several foreign firms have expressed an interest in licenses covering technical and scientific achievements of the Soviet aluminum industry, such as complex processing of alumina-containing raw materials (nepheline, alunite, kaolin), effective mechanized manufacturing processes in alumina production, high-output aluminum electrolysis equipment and its bus system in particular, electro-thermal manufacture of aluminum-silicon alloys, and other progressive processes of manufacture.

A particularly close and fruitful cooperation was established with the socialist countries within the framework of the CEMA, which now celebrates the 30th anniversary of its foundation.

An illustrative example of the effectiveness of this kind of cooperation is the systematic, close relationship between the aluminum-industry enterprises and organs of the USSR and the People's Republic of Hungary.

According to the provisions of the Soviet-Hungarian aluminum-industry cooperation agreement (an intergovernmental treaty), Hungarian alumina is processed in the aluminum factories of the USSR, payment being made by shipments of aluminum. This agreement contributes to the economic growth of this country, which is a friend of ours.

There has been scientific and technical cooperation since 1964 between the VAMI (USSR) and the ALUTERV - FKI [Aluminum-Industry Planning Enterprise - Research Institute for the Nonferrous Metallurgical Industry](Hungary), in which the aluminum-industry enterprises of both countries participate. During this period, studies were carried out on 40 subjects by joint effort, all aimed at solving the major problems of aluminum and alumina manufacture.

Within the framework of this cooperative effort, the Soviet party to the agreement gave 180 technical documentations to the Hungarian party, during the limited period of 1968-1978 alone. At the same time, the Hungarian party gave 158 such documentations to the Soviet party. Also during the same period, 198 Hungarian experts visited the USSR and 122 Soviet experts visited Hungary. Many joint inventions were developed within the framework of this cooperative effort. Scientists and experts from both countries hold seminars at regular intervals, where current topics of aluminum and alumina manufacture are discussed.

Licensing agreements also strengthen the cooperation between the USSR and the People's Republic of Hungary. Since 1973, six agreements were concluded for the transfer of patent rights and know-how concerning processes developed at the VAMI and implemented in Soviet aluminum factories, such as processes involving gallium production and improvements in alumina manufacture.

An important part of cooperation is the joint participation of experts from the two countries in aluminum-industry development projects in third countries. A good example for this is the joint participation in the designing and construction of the alumina factory in Biracs, Yugoslavia, which was started up in 1978 and which is the largest enterprise of its kind in Europe.

There can be no doubt about the fact that the ever-increasing cooperation between the aluminum and alumina industries of the USSR and the People's Republic of Hungary will continue to contribute to the technical and scientific growth of both industries and to strengthen the friendship that already exists between the peoples of the Soviet Union and Hungary.
[183-2542]

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WEAR RESISTANCE OF COATINGS OBTAINED BY SPARK-DISCHARGE POWDER DEPOSITION IN AN ELECTRIC FIELD

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, 1980 pp 31-33

TKACHENKO, Yu. G., PARKANSKIY, N. Ya., and YURCHENKO, D. Z., Kishinev and Kiev

[Abstract] The wear resistance and antifriction properties of coatings obtained by spark-discharge deposition of powder materials in an electric field on VT10 titanium alloys and ST3 and 1Kh18N9T steels were investigated. The process was conducted as follows: The powder material was fed from a feeder into the interelectrode gap formed by the working electrode (the anode) and the sample being processed (the cathode). A high-direct-current voltage in conjunction with low-voltage high-current pulses was applied to the electrodes. The ingress of powder particles into the working gap brought about the initiation of a low-voltage high-current discharge of an RC-generator. As a result of the interaction of the disperse material with the plasma of the spark channel, the former melted and was partly evaporated and deposited on the surface being treated. The experiments made use of both conductive materials and of dielectric B_4C with a dispersity of 70-150 microns. The phase composition and quality of the obtained coatings were studied by means of radiographic and metallographic analysis. Coatings made of chromium carbide and boron carbide were the most wear resistant and the coefficient of friction of B_4C on a titanium alloy substrate was considerably lower than on steel. The high rate of wear of the cobaltic coating on steel apparently can be explained by the presence of the high-temperature β-Co modification with a cubic lattice. Figures 2; references 3: all Russian.
[150-1015]

UDC 621.359.7

THE USE OF BIPOLARLY CHARGED POWDER IN FORMING POLYMER COATINGS

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, 1980 pp 56-59

KOTLYARSKIY, L. B., RUDENKO, V. M., and BOLOGA, M. K., Kishinev

[Abstract] Experimental investigation was carried out and parameters were compared of the process and of the quality of coatings obtained by unipolar spraying and by laminar deposition of bipolarly charged powder using industrial electrical sprayers with internal and external charging. The results of experiments showed that in unipolar spraying the growth of the powder mass slows down and, in time, ceases, whereas under conditions of the bipolar procedure the mass of powder being deposited constantly grows. On the other hand, the study of the ratio between the mass of powder deposited on the substrate and the mass of powder fed into the chamber of the sprayer also indicates that the effectiveness of the deposition of bipolarly charged powder is considerably higher than that of the unipolarly charged. The advantages of the bipolar method over the unipolar are likewise obvious if one considers the limiting thickness of deposited coatings, which is of importance in providing better insulation and anticorrosive properties. Under laminar deposition of bipolarly charged powder the limiting thickness of coatings may attain 3000 microns, compared with the 200 microns resulting from the unipolar method. Figures 4; references 5: 4 Russian and 1 Western.
[150-1015]

NEW CARBON-FIBER COMPOSITIONS

Minsk PROMYSHLENNOST' BELORUSSII in Russian No 3, 1980 pp 49-51

[Article by I. Yermolenko, corresponding member of the BSSR Academy of Sciences, I. Lyubliner, member of the senior scientific staff, and V. Dubkova, member of the junior scientific staff]

[Text] The Institute of General and Inorganic Chemistry of the BSSR Academy of Sciences has developed a new group of chemically modified carbon fibers whose structure includes metals, as well as various acid and base residues. Together with the complex of valuable properties characteristic of existing carbon materials, they also have predetermined chemical and sorptive activity, which makes it possible to obtain composite materials with new properties by a fundamentally new method.

Composite materials have begun to receive special attention over the past 15 years, although the idea of using two or more components forming a single composite is many centuries old. At the dawn of civilization, primitive man made laminated bows and mixed straw (reinforcing fiber) with clay (the matrix) in making bricks. The purpose of creating composites is to achieve a combination of properties not inherent in any of the initial materials (metal, ceramic, or polymer) individually. The use of composites makes it possible to improve the most important parameters of machines, assemblies, and instruments; in some cases, composites cannot be replaced at all by traditional materials. Thus, the development of space and oceanographic research has led to the creation of new types of composite materials having high strength, rigidity, heat resistance, low density, and high fatigue resistance. Among the most important of these are carbon-fiber composites with various matrices (metallic, inorganic, and polymeric).

Carbon fibers are a new type of fiber material whose industrial-scale production has only been mastered in recent years. The most common technique for manufacturing them is based on the heat treatment of various organic fibers under strictly controllable temperature-time regimes in specific media. The feedstocks are various chemical fibers produced from organic polymers, chiefly cellulose and acrylonitrile. The resultant

carbon fibers have a strength reaching approximately 100 kg-f/mm^2 in the first case and 350 kg-f/mm^2 in the second. Carbon-fiber materials can be produced in the form of filaments, rope, felt, belting, fabrics, knits, and nonfabric materials.

As a result of their structural characteristics, carbon fibers are strong, have relatively low bulk weight, and are distinguished by chemical stability, flexibility, electrical conductivity, dimensional stability of finished articles, and a low coefficient of linear thermal expansion. Their thermal characteristics are better than those of other heat-resistant fibers and most nonfibrous materials. Carbon fibers can withstand temperatures of 1650-2100° C in inert media.

All of these properties make carbon fibers one of the most promising of materials. For example, carbon plastics produced from them have physicomechanical indices exceeding those of existing vitreous plastics by a factor of 2-3. Moreover, articles fabricated from them now only have especially high physicomechanical indices but are also light in weight. Structural materials based on carbon plastics can successfully compete with scarce metals and alloys and are characterized by high fatigue resistance (four times that of the best types of vitreous plastics), high tensile and bending strengths, and high specific rigidity (five times that of steel). The bulk weight of assemblies fabricated from carbon plastics is 20-38% lower than that of steel assemblies. Replacement of some alloys in aircraft and earth-satellite components with carbon plastics has made it possible to reduce their weight by 30-50%. Special types of carbon plastics are widely used as heat-insulating coatings in astronautics. Current forecasts see them as occupying a leading place among structural materials in the aviation and space industries.

Despite their relatively high cost, carbon-fiber composites are finding increasing use in the manufacture of consumer goods, i.e., balls, hockey sticks, bows, arrows, ski poles, rackets, sports-car bodies, and extremely light-weight bicycle frames. Carbon-fiber composites are employed in the fabrication of assemblies and components for looms, chemical equipment, the rotary components of high-speed centrifuges, the flywheels of inertial automobile engines, etc. In medicine, biocompatible carbon fibers are employed in instruments for fabricating dental prostheses and in pins for joining bone. They are also used in musical instruments.

At the same time, the potentialities of carbon fibers have still been far from exhausted. Extensive research is being conducted on carbon materials in the USSR and abroad for the purpose of giving composites a wide range of desirable properties; this might open up areas of application in which ordinary polymers cannot be used.

Composite materials are multicomponent systems with numerous phase interfaces. Their characteristics are therefore governed to a considerable extent by the properties of the fiber filler and polymer matrix on the

one hand and by the presence of strong bonds at the polymer-fiber interface on the other. It should also be noted that many existing carbon fibers do not react effectively with resins, so that optimum composite physicomechanical properties cannot be achieved. Stronger interaction can be obtained through formation of chemical bonds between the surface of the carbon filler and the polymer material.

Scientists at the Institute of General and Inorganic Chemistry of the BSSR Academy of Sciences have been able to solve this problem. The active carbon fibers they developed are capable of serving two functions, those of filler and hardener, through the chemical interaction of their surface groups with the reactive groups of the binder. This results in strengthening of both the reinforcing filler (fiber) itself and of the final carbon plastic. Thus, modified carbon fibers have been used to produce reinforced epoxy compositions without addition of standard hardeners. This represents a fundamental difference between the new composite and those previously in use. They combine a high degree of homogeneity and thermostability with low density (1.17-1.23 g/cm^3) and a low coefficient of thermal expansion. When necessary, they can be made refractory, acid-resistant, and electrically conductive or given ion-exchange properties. The physicomechanical characteristics of the new composites are in no way inferior to those of traditional materials.

Thus, carbon fibers containing active elements can be used to replace toxic epoxy-resin hardeners, which makes the processing of composite technologically quite simple. The binder components need not be specially prepared, no mixing is required (since the resin serves as the binder), and industrial-hygiene conditions are improved by the absence of toxic hardeners.

Localization of the resin hardening process at the fibers can lead to "healing" of fiber surface defects and thus to strengthening of the filler itself. Moreover, this phenomenon can be utilized to produce permeable layers, e.g., filters and ion-exchange materials that retain their shape and are suitable for use in aggressive media.

Use of carbon fibers to make composites electrically conductive is of particular interest. Existing electrically conductive polymer materials generally contain finely dispersed conductive fillers (carbon black, graphite, and powdered metals). They become conductive only when the particles of these substances form chain structures, which requires large amounts of powdered filler and complex procedures to ensure that it has an ordered distribution. A high metal content causes the system to lose the major advantages inherent in polymer materials, specifically resulting in a substantial reduction in strength. Use of metal-containing carbon fibers in composites (with a low metal content in the fiber structure) not only gives them high electrical conductivity (since it provides continuous contact between the particles through formation of a reticular structure) but also enhances the strength of the material. By varying the

gravimetric metal concentration in the carbon fibers and the degree of filling, scientists at the Institute of General and Inorganic Chemistry obtained specimens of a conductive polymer composite that had a wide range of resistivities and were stable at temperatures of from 20 to 120° C; their coefficients of thermal expansion were low.

Use of carbon fibers in such multicomponent composites as polymer concrete is of practical value. This type of concrete, in which the cement is completely or partially replaced by a polymer binder, is essentially a plastic containing mineral fillers having different grain sizes. Such materials usually have high compressive and tensile strengths (up to 1000 kg/cm^2 and 200 kg/cm^2 respectively), high stability in most aggressive media, and good adhesion to all structural materials. It is best to use polymer concrete in facilities for chemical, mining, metallurgical, petroleum-refining, food-processing, and other enterprises where ordinary concrete and steel are ineffective as a result of exposure to aggressive media. The high static and dynamic strength, wear-resistance, and chemical stability of polymer concretes permit their use for chemically resistant floors, piping, and tanks for storage and transportation of chemically aggressive liquids and in many similar situations. This can all have a considerable economic effect at the national level (the annual loss due to corrosion of structures at chemical enterprises alone amounts to 170 million rubles, while the costs of repairing and refurbishing chemical-plant buildings and equipment require only 3-5 years of operation to equal those of new construction).

Polymer-concrete compositions containing electrically conductive additives are of undoubted interest. They are promising both from the standpoint of use as antistatic coatings and for production of electrically heated articles. The Institute of General and Inorganic Chemistry has developed conductive polymer concretes based on metal-containing carbon fibers and an epoxy binder with a mineral filler (quartz sand or cement). Blocks, sheets, and films can be fabricated from these materials.

The new polymer-concrete composite has a wide volume-resistivity range (from 30 to $1.7 \cdot 10^4$ Ω/cm), a low coefficient of thermal expansion ($10.6\text{-}26.8 \cdot 10^{-6}$ deg^{-1}), and high tensile, compressive, and bending strengths (240-260, 1100-1370, and 350-400 kg/cm^2, respectively). Components (heaters) fabricated from it reach the desired temperature within a few minutes. They can withstand prolonged heating at 90° C and their parameters remain stable. The good adhesion of polymer concrete to metals, wood, glass, and concrete permits its use for heated sheathing and coatings intended to drain off static electricity.

Another important application of the new polymer concrete is for accelerating the hardening of light structural concretes in monolithic constructions. The Institute of General and Inorganic Chemistry of the BSSR Academy of Sciences is also working to develop conductive composites of the carbon-concrete type that are microreinforced with carbon fibers and contain no polymer components.

Four Soviet Author's Certificates have been granted to those responsible for development of the above composite materials based on carbon fibers containing active elements.

[153-2478]

2478
CSO: 1841

UDC 539.3:678.067

ELASTICITY OF A HYBRID COMPOSITE MATERIAL BASED ON ORGANIC AND BORON FIBERS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 80 pp 399-403 manuscript received 16 Feb 79

MAKSIMOV, R. D. and PLUME, E. Z., Institute of Polymer Mechanics, Latvian SSR Academy of Sciences, Riga

[Abstract] The elasticity of a hybrid composite material consisting of an organic binder and a unidirectional reinforcement of many thin (8-10-μm diameter) high-strength organic and a few thick (100·μm·diameter) boron fibers, is calculated by considering first a repeatable small "anisotropic organic fiber + isotropic binder" element and then a large "isotropic boron fiber + anisotropic matrix" element. Formulas for the moduli of elasticity, longitudinal and transverse, as well as for the corresponding shear modulus, are derived by averaging the appropriate Poisson ratios and integrating over the height of an element in the Voigt-Reiss approximation. These formulas were programmed on a Unified System YeS-10-30 computer, and numerical calculations were made for a hardened EDT-10 epoxide binder with a fixed 0.4 volume fraction of reinforcement consisting of boron and high-strength organic fibers in a variable ratio from 0:1 to 1:0. The agreement with experimental data based on the slope of stress-strain diagrams is sufficiently close for engineering purposes but, as the volume fraction of boron fibers increases, this component ceases to be quite isotropic and corrections become necessary to account for it. Figures 2; references 7: 6 Russian, 1 Western.
[182-2415]

UDC 539.3:678.067

CONCERNING THE MULTIPURPOSE DESIGN OF FIBROUS COMPOSITE MATERIALS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 80 pp 404-408 manuscript received 17 Jul 79

BRYZGALIN, G. I. and KOPEYKIN, S. D., Volgograd Polytechnic Institute

[Abstract] The problem of designing a composite material for a wide range of applications under various loading conditions is considered in terms of a mechanical model and multitarget parameter optimization. For a fibrous structure operating in a biaxial plane state of stress the model consists of five elements: two orthogonal layers of reinforcing fibers with a binder each and with a binder interlayer between them. An analysis based on extension of the uniaxial case, with the widths and the thicknesses of both fiber layers as control parameters, yields four target functions which characterize the strength of the composite material. These as well as the density and the moduli of elasticity in both directions are to be maximized, while the cost of the material and the difference between the thermal expansivities in both directions are to be minimized. Through averaging and normalizing, the optimization is reduced to maximization of a single generalized target function symmetric with respect to the partial ones. The algorithm of this process based on the Monte Carlo method is shown schematically. It has been applied to such composites ws glass-epoxy, boron-epoxy, boron-aluminum, VL1D steel with VT6s titanium alloy or with V95 aluminum alloy, and pure aluminum with V95 aluminum alloy. For given intervals of the partial optimization parameters, the steel-V95 (aluminum alloy) composite was found to be the best on the basis of the maximum of the generalized parameter. Figures 2; references 5: 4 Russian, 1 Western.
[182-2415]

UDC 539.4:678.067.9

CHARACTERISTIC FEATURES OF FATIGUE FRACTURE OF FIBROUS COMPOSITES WITH A METALLIC MATRIX

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 80 pp 409-417 manuscript received 14 Jan 80

MILEYKO, S. T. and ANISHCHENKOV, V. M., Institute of Solid-State Physics, USSR Academy of Sciences, Moscow Oblast

[Abstract] An experimental study of fatigue fracture was made for the purpose of constructing a mechanical design model of fibrous composites with a metallic matrix under cyclic loads. The matrix consisted of foils

of quenched and aged D-16 aluminum alloy or a non heat-treated Mg-Zn aluminum alloy. Boron fibers or chromium-nickel steel wires which retain high strength and full hardness in the preparation process served as the reinforcement. Specimens in the form of flat cantilever beams (50 x 5 mm, 1.50-1.75 mm thick) were tested at resonance in the transverse vibration mode. Two different mechanisms of brittle fatigue fracture in the case of boroaluminum were revealed: cracking of the aluminum matrix when the volume fraction of boron fibers is low and cracking of the boron fibers when their volume fraction is high, both mechanisms operating within the intermediate range. Accordingly, there is no linear dependence of the fatigue strength on the boron content. Fatigue strength rapidly increases as the boron content increases up to 20% and does not vary with boron content within the 40-50% range, but depends on fiber characteristics. A small addition of steel wires tends to make the fracture ductile and, depending on the volume fraction of boron fibers, raises the fatigue strength of the composite with a narrowing of the variance. Figures 6; references 10: 8 Russian, 2 Western.
[182-2415]

UDC 539.4:678.067

EDGE EFFECTS AND STRESS CONCENTRATION IN MULTILAYER PLATES OF COMPOSITE MATERIAL

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 3, May-Jun 80 pp 424-435 manuscript received 3 Jan 80

BLUMBERG, N. N., Latvian State University imeni P. Stuchki, Riga, TAMUZH, V. P., Institute of Polymer Mechanics, Latvian SSR Academy of Sciences, Riga

[Abstract] Edge effects and stress concentration in multilayer plates of composite material are calculated according to a model which compromises between exact solution of differential equations in the theory of elasticity, applying the method of finite elements at the micromechanical level, and approximate solution by the method of hypotheses at the macromechanical level. A typical case is a rectangular laminate plate consisting of three layers of hard silicate or acrylic glass and two interlayers of a soft polymer binder, cylindrically deformed in a uniform temperature field. While displacements of the glass layers are related to forces and moments according to the classical Kirchhoff-Love theory, normal and shearing stresses in the binder are described approximately by a more precise version of the basic Ambartsumyan theory. Generally the state of stress and strain is sought in the form of two Fourier series in the coordinate plane parallel to the plate and is calculated by the method of boundary functions. The iterative algorithm constructed for this porpose involves integration over and collocation between two lateral

edge zones and the internal zone across either the length or the width of the plate. A simple example is used for demonstration, namely a symmetric, infinitely long place of finite width separating two media at different temperatures and pressures. The results of calculations indicate high stress concentration at the edges. The zeroth approximation corresponds to the degenerate case of a plate with a "soft filler;" successive approximations add corrections for thermoelastic stresses in the glass due to heating or cooling and satisfy the no-load boundary conditions for the binder. Figures 2; references 10: all Russian.
[182-2415]

UDC 678.05:678.067

DEVICE FOR PRODUCING CONTINUOUS FIBERGLASS REINFORCED PLASTICS

Kiev KHIMICHESKAYA TEKHNOLOGIYA in Russian No 3, 1980 submitted 14 Mar 78 signed to press 7 May 80, pp 20-23

SHOROKHOV, V. M., Institute of Chemistry of High Molecular Compounds, UkSSR Academy of Sciences

[Abstract] A description is given of a device for forming samples of composite polymer materials at any temperature from room temperature to 300° C with an aging accuracy of ± 3° C at forming pressures of 0 to 0.98 kg/cm^2 (vacuum molding) and a rate of heating from 1 to 9° C and rate of cooling from 0.2 to 12° C/minute in the presence or absence of stretching stresses in the reinforced continuous fibers. The device can be used to produce solid and laminar flat 305 x 305-mm samples from 0.1 to 18 mm thick and polymer materials reinforced by glass, mineral or synthetic fibers or shallow panels of a given shape.
[211-2791]

SHORTCOMINGS IN UTILIZATION OF METAL SCRAP

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 15 Aug 80 p 2

[Article by A. Voronov, USSR deputy minister of ferrous metallurgy, chief executive officer of Soyuzvtorchermet All-Union Production Association: "En Route to Open-Hearth Furnaces"]

[Text] The performance figures of Soyuzvtorchermet for the first half of the year are gratifying: we shipped off 47,000 tons of high-quality scrap above target to metallurgical plants, and we procured 7,000 tons above target. But far from all reserve potential has been utilized.

We still have a poorly-developed network of receiving stations and production shops in Kazakhstan and Tyumenskaya Oblast, where large quantities of scrap metal accumulate. Due to this fact we fail to collect in these areas each year many hundreds of thousands of tons of scrap and are forced to haul scrap over long distances for recycling.

There have also been problems with putting on-stream facilities at newly-completed shops and plants. Vtorchermet's Karaganda Plant, for example, went into operation last year, but it is still operating far below designed capacity. This is affecting deliveries of scrap to the Karaganda and Magnitogorsk metallurgical combines and to the Chelyabinsk and Uzbek metallurgical plants.

A poor job of processing through railroad cars is being done, with above-standard turnaround time, by the Moscow, Irkutsk, and Yaroslavl' Vtorchermet associations and Vtorchermet's Kolomna Plant. They are not adequately serving the metallurgical workers of Novolipetsk, Siberia, and Cherepovets.

Unfortunately we have sometimes had a failure of communication with associated plants, although it would be difficult today to find a business executive who is unaware that scrap is an indispensable metallurgical raw material and that it is five times cheaper to collect, transport and process scrap than, for example, to smelt pig iron from iron ore. But modern methods of procuring and processing scrap are not employed everywhere. In any case many are in no hurry to acquire special equipment for this purpose.

Indicative in this regard is a letter from Deputy Minister of Heavy and Transport Machine Building B. Kulik: "The Novocherkassk Machine Building Plant imeni Nikol'skiy employs scrap steel in Bessemer converters.... In order to reduce the hauling of scrap steel in from elsewhere and to employ production process waste in the charge, a ministry order calls for installing here a 250-ton baling press in 1983."

All this is correct, with the exception of the timetable: at Vtorchermet enterprises such presses are installed in a maximum... of three months. This means that for several years more the people in Novocherkassk will be continuing to require scrap prepared by other enterprises, at substantial hauling costs. The machine building plants of this same ministry in Orenburgskaya Oblast also require several thousand tons of prepared secondary raw material, although they themselves could handle things locally, if the proper equipment were installed.

The Chelyabinsk Machine Tool Plant imeni S. Ordzhonikidze Association possesses large quantities of scrap metal. They should manage it properly, for it would not be so difficult to process it themselves. The Chelyabinsk people, however, receive almost as much secondary raw materials as they supply.

We have 9,000 scrap users just among machine builders. These include enterprises which rival metallurgical enterprises in volume of steel and pig iron production. One can easily imagine how much prepared secondary raw material they need. It travels here and there throughout the country, taking up freight cars and making scheduling problems for the Ministry of Railways. In order to avoid cross hauls and set up processing and utilization of scrap metal locally, Soyuzvtorchermet asked 35 ministries to look for possibilities of reducing the hauling of scrap from elsewhere. Many did not respond at all, while some preferred merely to go through the motions of replying, stating meager figures. A. Myslov, for example, deputy chief of the supply administration of the Ministry of Chemical and Petroleum Machine Building, reported: "We have found the possibility of reducing annual deliveries by 3,000 tons." M. Klipanov, a colleague from the USSR Ministry of Coal Industry, replied: "We are reducing stocks by 15,000 tons."

We did not limit things to a mere request for information. For large-scale scrap suppliers we determined equipment requirements, drew up an equipment list and proposed that the Ministry of Machine Tool and Tool Building Industry manufacture presses, alligator shears, and other equipment. We were not pleased with the reply: they are going to produce considerably less than half the ordered quantity, and even that will take some time.

When there is no equipment, there is no processing. And this means that enormous reserve potential will not be brought into action soon. Enterprises of the Ministry of Automotive Industry, the country's second largest supplier of scrap metal, surpassed only by the USSR Ministry of

Ferrous Metallurgy, use the excuse of lack of equipment as if it were a shield. At the present time the automotive plants are failing to process half of the scrap they generate. And yet they possess considerable capability in this area. But different plants use this capability to different degrees. One of the best is the Gor'kiy Automotive Plant, where scrap is collected strictly by groups and grades directly at the machine tools and presses, in foundry carts. This scrap is regularly taken directly to the scrap processing shop. There scrap is compressed and baled, and steel chips are ground up.

The same can be said about the Riga RAF Plant. Quite recently consists were leaving here, one after the other, for Yelgava: they were carrying oversize scrap to a Vtorchermet shop for processing. But the plant executives, with the assistance of the party committee, put an end to this practice. The automotive plant people now process all scrap themselves and also themselves utilize a large part of it. As a result the freight car requirements of the Riga people have become considerably reduced. Their colleagues in the AZLK, AvtoZIL, BelavtoMAZ and other associations which possess modern equipment but are failing to process much of their scrap could learn from them.

The party Central Committee decree entitled "On the Work of the Metallurgy, Machine Building and Construction Ministries to Improve Quality of Metal Products and Efficient Utilization of Metal on the Basis of Adoption of Low-Waste Processes in Light of the Demands of the November (1979) CPSU Central Committee Plenum" specifies, among other sources of losses, improper utilization of metal, unsatisfactory metal storage, and outright waste.

Novyy Urengoy is a small town in Tyumenskaya Oblast. People from the Ministry of Construction of Petroleum and Gas Industry Enterprises for a long time were collecting reject structural members, machinery parts and assemblies, and scrap metal fragments. But a collection and storage area was needed to really do anything, and the scrap was buried in the ground by bulldozers.

Every year 400,000 steel drums are hauled to the North, but aviators return only one fourth of this number back "to the mainland." The remainder are dumped in the water or relegated to trash dumps. The manufacture of these drums involves the annual consumption of 12-15 thousand tons of short-supply sheet steel.

The people at Vtorchermet of course cannot keep track of each and every drum. Obviously USSR Gossnab and RSFSR Goskomnefteprodukt must address this problem in a more rigorous manner and adopt a regulation which applies to everybody: if you want to receive a full drum, turn back an empty one. The same applies to the allocation of various equipment and machinery, including agricultural. Half a million tons of metal is standing around rusting on the fields and farms of the RSFSR Ministry of Agriculture, a figure which represents one fourth of the annual plan target of the entire ministry.

In order to deliver raw materials to metallurgical plants more rapidly, Vtorchermet is conducting comprehensive surveys of enterprises and organizations. Representatives of Vtorchermet have visited 907 enterprises of the USSR Ministry of Construction Materials Industry and have located more than 80,000 tons of ferrous metal scrap and waste which should be turned in. We reported specific addresses to the ministry, but measures are being taken extremely slowly.

There are many similar examples in other branches as well.

One must also reproach the Ministry of Railways for the inefficiency with which it hauls scrap metal and for its disinclination to organize opportunity loading of empties. A total of 50,000 tons of metallurgical raw materials, for example, has accumulated in Penzenskaya Oblast, but the railroaders are not spotting for loading those empties which are heading for Magnitogorsk. Outdoor storage areas are filled to overflowing with scrap at the bicycle plant, Belinsksel'mash, Penzmashzavod, and the Tyazhpromarmatura Plant.

Railroaders in the Bashkir ASSR, Ul'yanovskaya, Kalininskaya, Novgorodskaya, and Pskovskaya oblasts, as well as in the Baltic republics have failed to find reserve capability to improve their performance. This leads to difficulties in supplying raw materials to the Magnitogorsk and Beloretsk combines, the Chelyabinsk, Cherepovets and Novolipetsk metallurgical plants. But the Ministry of Railways went even further: it adopted restrictions on freight hauling on the Eastern Siberian and Transcaucasian railroads. This means that the Amurstal', Sibelektrostal', Petrovsk-Zabaykal'skiy and Rustavi metallurgical plants and the Azerbaijan Tube Rolling Plant will soon be operating from car to furnace, with unprepared scrap.

As is evident, both we and our associate organizations and enterprises possess considerable reserve potential. This can and must be fully utilized during the days of the pre-congress labor watch.
[185-3024]

3024
CSO: 1842

NEW TECHNOLOGY FOR PRODUCING PARTS FROM PRESSED STRUCTURAL SHAPES

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 10, 1979 pp 23-26

[Article by V. V. Shalavin, A. D. Komarov, P. S. Tyukhtin, and F. V Kirov: "New Technology for Producing Parts from Pressed Structural Shapes"]

[Text] The designs of modern aircraft, ships, machines and mechanisms call for the extensive use of parts made out of thin-walled pressed structural shapes: linear parts with single, varying and alternating curvature with a constant and varying change in the angle of the structural shape and with straight and oblique cuttings. The precision of the geometric parameters, the reliability of operation and the production cost of the parts are determined basically by the technology of their manufacture.

However, the technology that is used for producing the parts from pressed structural shapes has substantial shortcomings, of which the following are basic: the manufacture of the parts requires several operations, there are significant technological allowances, there is a need for a large amount of equipment and technical rigging, a long period of time is required to prepare for production and so forth. Moreover the labor intensiveness of producing the parts is high due to the large amount of manual finishing work, which in some cases amounts to as much as 70 to 80 percent of the total labor intensiveness of producing the parts.

For the first time in world practice a technology has been developed for producing parts from pressed structural shapes by means of stamping with an elastic agent. Using this technology within one movement of the hydraulic press there is produced a bend at a constant and varying radius, a constant and varying change in the angle of the structural shape, a straight and oblique cutting of the structural shapes with T-, L- and U-shaped sections, which are made of aluminum alloys and other materials. To accomplish the processes are required only a standard container that has been equipped with an elastic agent and interchangeable mandrels (Figure 1).

A straight structural shape billet is placed in the groove of the mandrel. Under the pressure of the elastic agent that has been placed in the container the structural shape is bent, curved and cut.

Parts from structurally shaped billets are stamped with both a compression and a stretching of the wall (Figure 2, a, b). Parts with an alternating curvature, the manufacture of which is done using traditional methods is expecially labor intensive, are stamped using the new technology in one motion of the press also (Figure 2, c).

The device for stamping parts from structural shapes using an elastic agent is patented (1).

A special grade of polyurethane, SKU-7L, is used as the elastic agent. As industrial tests have shown, it is not expedient to use rubber for the stamping because when used in such heavy conditions it rapidly disintegrates (there is much deformation at pressures of up to 1,000 kilogram force per square centimeter).

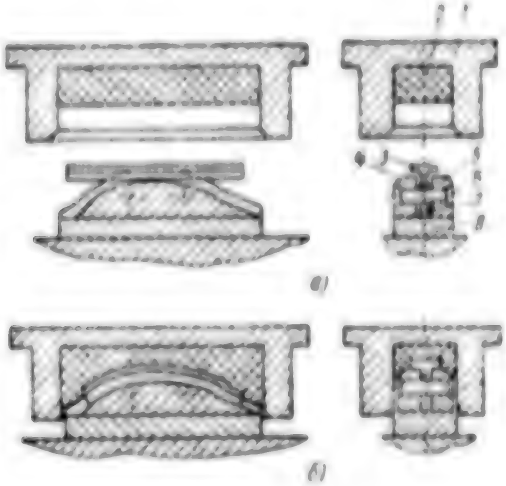

Figure 1. Diagram of the stamping of parts from pressed structurally shaped billets using an elastic agent. a - the device in the initial position; b - in an operating position; 1 - the container; 2 - the elastic agent; 3 - the structurally-shaped billet; 4, 5 - mandrel plates; 6 - bolt; 7 - gasket; 8 - lower plate

On the basis of the analysis of the product list of parts from the billet-stamping shops of a plant, a classifier of parts for transfer to stamping by means of polyurethane has been compiled (Figure 3). Parts are stamped from structural shapes that are manufactured from these materials: D16M, D16T, D16T in a freshly-hardened state, V95 and MA8. The structural shapes have these dimensions of sections: beam thickness up to 4.5 mm, wall thickness up to 4 mm; beam width to 50 - 60 mm; and wall height up to 100 mm.

The classification of parts was done according to design-technological and geometric parameters. By size the parts are combined into four groups that are more characteristic for a given plant: length up to 500 mm, from

500 to 700 mm, from 700 to 1,000 mm and greater than 1,000 mm. For the manufacture of the first three groups of parts, standard containers with working sizes of chambers in the range of 500 X 50, 700 X 50 and 1000 X 60 mm are designed, manufactured and adopted for production.

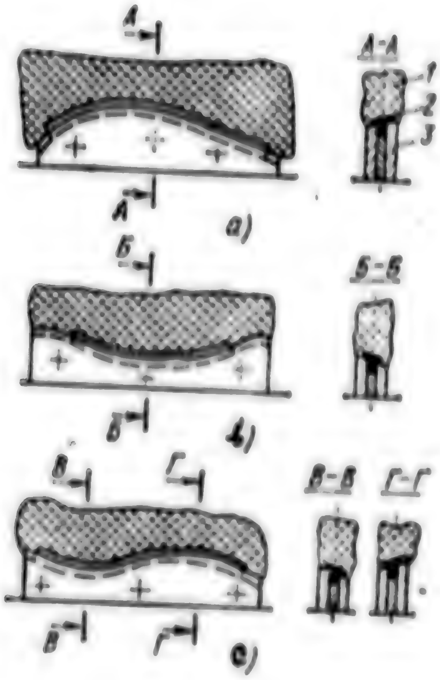

Figure 2. Diagrams of the stamping of parts from pressed structural shapes: a - with compression of the wall of the structural shape; b - with stretching of the wall of the structural shape; c - alternating curvature; 1 - elastic agent; 2 - structural shape; 3 - mandrel.

Such containers with right-angled chambers of the slotted type for working with polyurethane pressure of up to 1,000 kilogram force per square centimeter as original design solutions were designed and manufactured for the first time.

For example, to ensure the necessary durability of the container with a grooved chamber with dimensions of 500 X 50 mm (Figure 4) along the short sides of the chamber were installed semi-cylindrical bushings, which had been turned with the smooth sides in (2). This made it possible to retain the rectangular shpe of the chamber and at the same time eliminate the concentrators of stress in the most dangerous places of the chamber (in the corners), which ensured an increase in its durability and service life by several times (the design of this container has been patented) (3). The container is installed on a high-speed hydraulic press of the piston

type with a 250 ton-force. More than 90,000 parts have been stamped in the container.

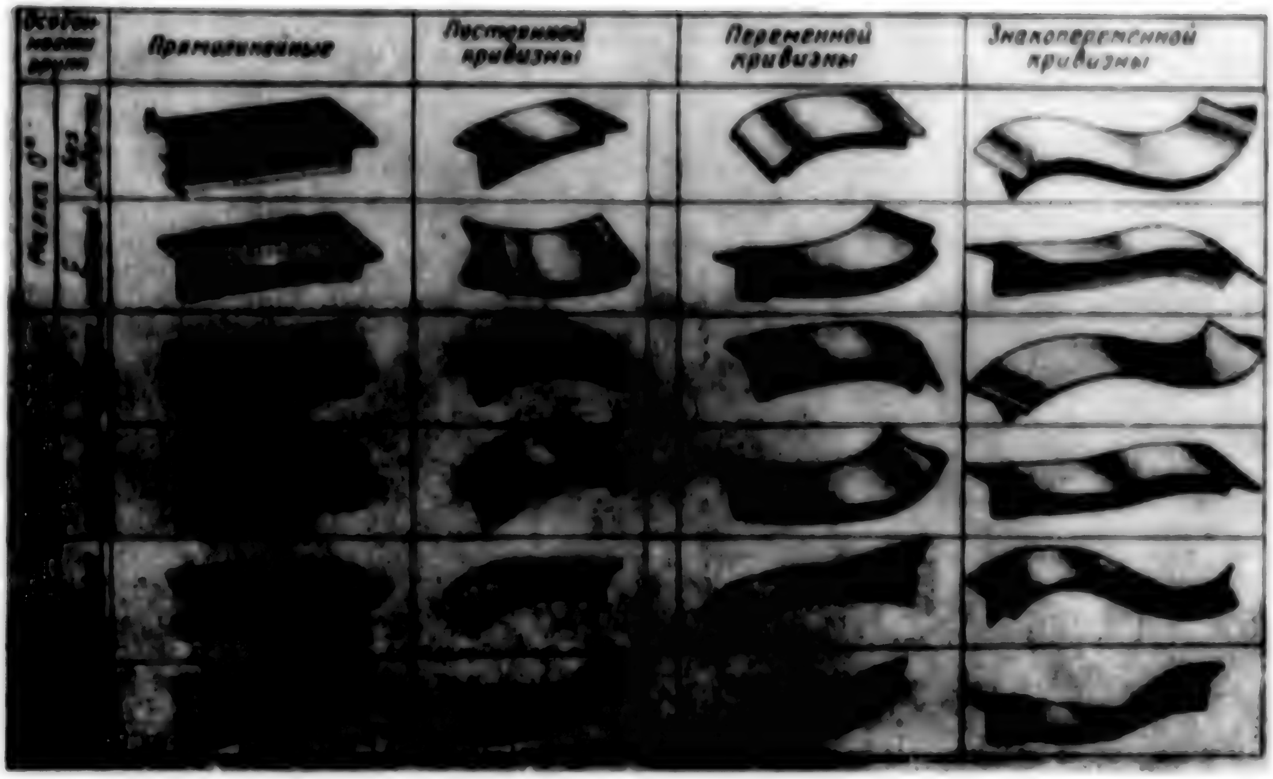

Figure 3. Classifier of parts from pressed structural shapes, which have been stamped by means of polyurethane. Key: 1 - Group features; 2 - straight; 3 - constant curvature; 4 - varying curvature; alternating curvature; 6 - Bevel 0 degrees, with cutting and without cutting; 7 - Constant bevel, with cutting and without cutting; 8 - Varying bevel, with cutting and without cutting.

To provide for the durability of a container with a grooved chamber of dimensions 700 X 50 mm an improved design has been developed. A rim manufactured from sheets of highly durable steel (Figure 5) is installed in the chamber with bushings along the tight fit. The container is installed on a high-speed hydraulic press of the piston type with a 250 ton-force. More than 15,000 parts have been stamped.

To provide for the durability of a container with a grooved chamber of dimensions 1,000 X 60 mm a basically new design has been developed. The container's chamber is compound and constitutes separately manufactured long

and short walls, which have been fastened by the ends by clamps (Figure 6). The camber of the long wall of such a chamber is greater than for the containers that are cited above. However as compared with the estimated rimmed chamber of the same dimensions, its sizes were considerably less.

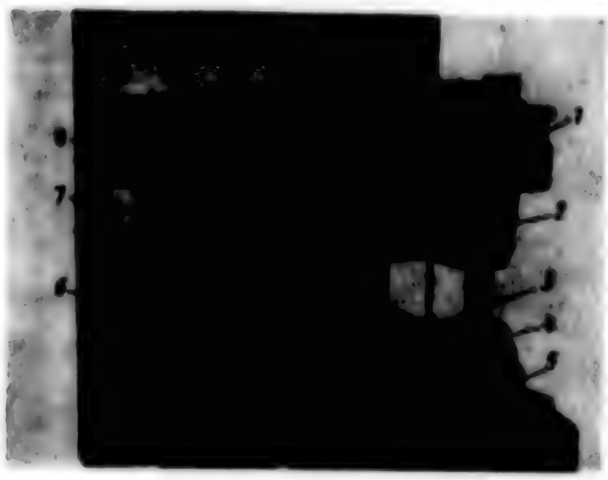

Figure 4. Overall view of a container with a grooved chamber with dimensions of 500 X 50 mm: 1 - Upper plate; 2 - chamber; 3 - mandrel; 4 - pin; 5 - lower plate; 6 - Guide column; 7 - Guide sleeve; 8 - Clamp.

The container is installed on two connected for this high-speed hydraulic presses of the piston type with a 160 kilogram-force each. For the synchronous shifting of the pistons there has been developed a system for synchronizing the hydraulic and electrical circuits of the presses. The synchronization system is executed by feed-back, which traces the shifting of the pistons.

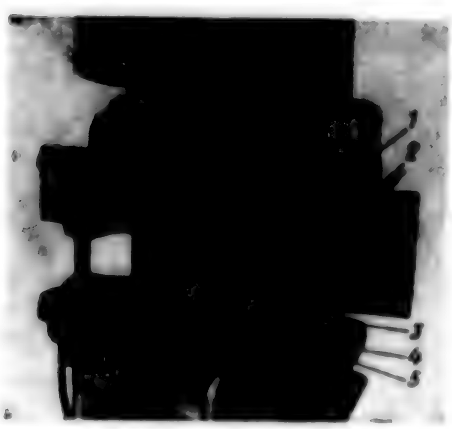

Figure 5. Overall view of a container with a grooved chamber with dimensions of 700 X 50 mm: 1 - Upper plate; 2 - Rim; 3 - mandrel; 4 - Pin; 5 - lower plate.

At present a container design has been developed that has a grooved chamber with dimensions of 2,000 X 60 mm.

In the billet-stamping shop of the plant a special sector has been created with production lines for stamping parts from pressed structural shapes using polyurethane. In each production line there are two hydraulic presses, which are equipped with containers, and two cooling racks with mandrels that are used for the stamping. The mandrels are kept next to the working spaces in simple and convenient cooling racks.

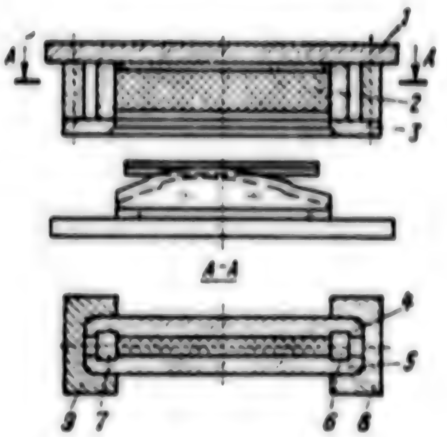

Figure 6. Diagram of a component container with a groved chamber with dimensions of 1,000 X 60 mm: 1 - upper plate; 2 - Elastic agent; 3 - Support plate; 4, 5 - Lengthwise wall; 6,7 - Front wall; 8,9 - Clamp

To reduce the labor intensiveness of designing and manufacturing the mandrels and also to reduce their cost a classification system for mandrels has been developed. The optimal design of a mandrel is determined by making use of the classifier at the stage of designing the technological process for manufacturing a part. This has made it possible to improve the quality of parts and to increase labor productivity when using grouped mandrels.

According to design features the mandrels are broken down into three basic groups: simple mandrels, on which forming operations (bending, changing the angle of a structural shape, and cutting) are performed; complex mandrels, on which along with forming operations is performed the calibration of individual sectors or of an entire part by means of various calibrating elements; special mandrels, on which simultaneously with forming operations is performed the elimination of crimps on the wall of the structural shape which occur during bending, particularly along a small radius. When necessary these mandrels are used with calibrating elements.

According to technological features the mandrels are broken down into two basic groups: mandrels for single-item stamping, on which in one motion of the press one part is manufactured; and mandrels for group stamping, on which several parts are manufactured in one motion of the press.

In turn, mandrels for group stamping are broken down into two sub-groups: mandrels with the consecutive feeding of billets (Figure 7, a); and mandrels with the parallel feeding of billets (Figure 7, b).

Mandrels with the consecutive feeding of billets are used for stamping chiefly short parts from structural shapes with T, L, and U-shaped sections.

Mandrels with parallel feeding of billets are used to stamp parts from structural shapes with L-shaped sections. For example, left and right parts are stamped on such mandrels in one motion of the press.

The length and width of a mandrel must be equal to the length and width of the container's chamber with consideration given to the needed clearance (no less .2 to .5 mm to a side). When a smaller mandrel is used, polyurethane is extruded in the clearance between the mandrel and the wall of the container's chamber, which leads to premature wear.

Mandrels of a simple form for stamping small batches of parts at comparatively small pressure of up to 400 to 500 kilogram-force per square centimeter can be manufactured out of wood-resin laminate, recycled aluminum or plastic.

Mandrels of a complex form or for stamping large batches of parts at a high pressure of polyurethane of 500 to 1,000 kilogram-force per square centimeter and greater are manufactured out of D16 material in a hardened state.

Mandrels for stamping parts out of pressed structural shapes by means of polyurethane are manufactured on machine tools having digitally programmed control (ChPU). For this they use three-coordinate machine tools with the designations FP-7M and FP-17. The use of CHPU machine tools instead of regular machine tools makes it possible to significantly reduce the labor intensiveness of manufacturing mandrels.

Power and precision parameters are crucial to the new technological process. They include: the value of the flexible performance of the structural shape during bending and changing the angle of the structural shape and the value of the deforming pressure of the elastic agent.

The value of the flexible performance of the structural shape is determined in regard to the value of the radius of the bending of the part and the angle of change to the structural shape and is taken into consideration when processing mandrels on CHPU machine tools.

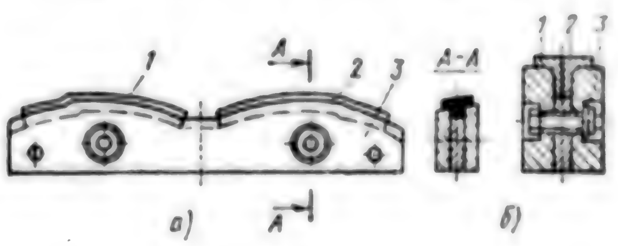

Figure 7. Mandrel for group stamping with consecutive (a) and parallel (b) feeding of billets: 1,2 - Billet; 3 - Mandrel.

To estimate the deforming pressure of the elastic agent that is required for bending the structural shapes, we have this formula (2):

$$q = \frac{2\left(\frac{EJ_{\text{уп}}}{\rho_{\text{н}}} + \frac{KJ_{\text{пл}}}{\rho_{\text{н}}^{n}}\right)}{b\,(L - \rho_{\text{н}}\varphi)^{2}}, \tag{1}$$

where E - is the module of normal elasticity; K, n, - are constants of the approximating curve of reinforcement; J_{yp} - is the moment of inertia of the flexible-deformed zone of the section in relation to the neutral axis; J_{pl} - is the adjusted moment of inertia of the pliable deformed zones of the transverse section in relation to the neutral axis; Pn - is the radius of the curvature of the neutral layer of the curved element; b - is the width of the flange of the structural shape; L - is the length of the sector of the structural shape that is being bent; and ϕ - is the angle of the bend.

The moment of inertia of the flexible-deformed zone of the section in relation to the neutral axis J_{yp} and the adjusted moment of inertia of the pliable deformed zones of the transverse section in relation to the neutral axis J_{pl} are defined in the work (4).

In practical estimates the deforming pressure of the elastic agent that is required for bending the structural shapes can be determined according to this simplified formula:

$$q = \frac{2KJ_{\text{пл}}}{b\,(L - \rho_{\text{н}}\varphi)^{2}\,\rho_{\text{н}}^{n}}. \tag{2}$$

Formulas (1) and (2) show that when $Pn\phi \rightarrow L$ the value of the pressure of the elastic agent is $q \rightarrow \infty$. For this reason when determining the deforming pressure of the elastic agent when $L = Pn\phi$ or is nearly equal to this value use is made of a rigid covering, which is installed on the flange of the structural shape and which increases the length of the portion of L that is being bent.

The stress of the press during the stamping of parts from pressed structural shapes by means of an elastic agent is determined according to the formula

$$P = k_{z}qF, \tag{3}$$

where k_z - is the coefficient of stress reserve of the press taken as equal to 1.2 - 1.3; q - is the deforming pressure of the elastic agent that is required for shaping the part; F — is the area of the working surface of the elastic agent.

When stamping parts from pressed structural shapes by means of polyurethane as compared with traditional technological processes one achieves a significant savings by decreasing labor intensiveness in the manufacture of parts by eliminating heavy manual finishing work and combining operations; by reducing the expenditure of materials by eliminating technological shrinkage allowances; by reducing the amount of stamping rigging and equipment; by reducing the time periods for preparation of production; and by improving the quality of the parts. Moreover, a complete interchangeability of the stamped parts is achieved and production noise is significantly reduced.

At present at the plant approximately 1,000 designators of various parts made of pressed structural shapes are stamped using polyurethane, which has provided an economic savings of more than 220,000 rubles per year.

The new technology for manufacturing parts from pressed structural shapes by means of polyurethane stamping continues to be adopted in many sectors of industry.

Conclusions. 1. A new highly-efficient technology for manufacturing parts from structural shapes using polyurethane stamping and original designs of grooved containers and mandrels have been developed and are being used in production.

2. A classifier of parts that are stamped by polyurethane from pressed structural shapes and a classifier of mandrels have been developed.

3. A process for manufacturing mandrels on ChPU machine tools has been developed and adopted.

4. On the basis of the research that has been performed formulas have been obtained to estimate the power and precision parameters of the process.

5. Due to the adoption into production of the new technology for manufacturing parts from pressed structural shapes by means of polyurethane stamping significant economic savings are being realized by production.

FOOTNOTES

(1) Patent No. 575160. Byulleten' "Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki" [Discoveries, inventions, industrial models and commercial emblems], 1977, No. 37.

(2) Shalavin, V. V., Komarov, A.D., and others. Shtampovka detaley iz pressovannykh profiley elastichnoy sredoy [Stamping parts from pressed structural shapes by means of an elastic agent], Collection, "Shtampovka v melkoseriynov proizvodstve" [Stamping in small-scale production], Moscow, MDNTP, 1979, pp 79-85.

(3) Shalavin, V. V., Komarov, A. D., and others. Ustroystvo dlya shtampovki elastichnoy sredoy [A device for stamping using an elastic agent], Polozhitel'noye resheniye po zayavke No. 2592643/27-27 [Positive solution to order No. 2592643/27-27] of 12.10.78.

(4) Lysov, M. I. Teoriya i raschet protsessov izgotovleniya detaley metodami gibke [Theory and evaluation of processes for manufacturing parts using bending methods], Moscow, Mashinostroyeniye, 1966, p 236.

[84-8927]

8927
CSO: 1842

UDC 669.295:539.374.4

ISOTHERMAL STAMPING OF TITANIUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian
No 6, Jun 80 pp 53-56

YELAGINA, L. A., BRUN, M. Ya. and BRAILOVSKAYA, B. F.

[Abstract] The isothermal stamping of VT3-1, VT9 and VT6 two-phase titanium alloys makes it possible to diminish resistance to deformation owing to the possible development of superductility, although certain conditions have to exist. A decrease in the strain rate in the isothermal swaging of VT9 (950^{0} C) lowers the yield strength of this alloy independently of initial structure. To achieve a good homogeneous structure in isothermal stamping it is necessary that a fine-grain structure exist in the alloy. This was true for the three alloys studied and, when achieved, it was possible to lower or completely eliminate residual stresses and warping although there is the possibility of warping during cooling and extracting the part from the die. The mechanical properties of turbine blades produced under conditions of superductility were no better than if they had been treated by high-temperature thermomechanical treatment but did differ by a high homogeneity in different zones. The advantage of isothermal stamping is greater dimensional precision and a set of stable mechanical properties. A. L. PILIPENKO, S. A. KAS'YANOV, L. B. FREYMEN, L. G. VERTYUKOVA, N. S. SEVAST'YANOVA and O. P. YEVMENOV participated in this work. Figures 1; references 13: 7 Russian, 6 Western.
[183-6368]

UDC 621.74.045

COMPARISON OF TWO ORIENTED-CRYSTALLIZATION CASTING TECHNIQUES

Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, 1980 pp 16-17

LEBEDEV, P. V., KOTOV, V. F., GONCHAROK, A. V. and SHATUL'SKIY, A. A., Rybinsk Aviation Technology Institute

[Abstract] The principal difference between the two most widely used oriented-crystallization casting techniques is that in the first case the molten metal in the shell mold crystallizes with respect to a water-cooled copper chill (direct cooling), while in the other the metal is cast into a ceramic-bottom mold placed on a cooler (indirect cooling). The direct cooling technique is found to be superior to its indirect-cooling counterpart in several respects such as a more fine-grained (columnar) structure, higher notch impact strength, and a more stable technology, as well as a more rapid crystallization rate. One disadvantage of the direct-cooling method is that the equipment (molds) cannot be used for the other method. References 5: all Russian.
[175-1386]

UDC 539.37+662.74

PRODUCTION OF CARBON FILAMENT REINFORCED GRAPHITE

Moscow KHIMIYA TVERDOGO TOPLIVA in Russian No 3, May/Jun 80 pp 109-114
manuscript received 27 Jul 78

KRIVOSHEIN, D. A., GORBUNOVA, G. P. PETROV Yu. N. et al.

[Abstract] Graphite exhibits a number of unique properties, but it has a very low resilience. The aim of this study was to determine the possibility of producing reinforced graphite with an increased resilience by means of hot extrusion. A mathematical model was developed to determine the optimal production conditions. The reinforced graphite produced by hot extrusion showed a five-fold higher resilience than the VPP brand graphite. The crystalline network of the hot extruded material was comparable to that of graphite obtained by traditional methods. Figures 2; references 18: 14 Russian, 4 Western.
[215-7813]

UDC 539-37

THE EFFECT OF COKE'S ADSORPTION CAPACITY ON THE PROPERTIES OF HIGHLY STABLE GRAPHITE

Moscow KHIMIYA TVERDOGO TOPLIVA in Russian No 3, May/Jun 80 pp 117-120
manuscript received 17 Jul 78

FILIMONOV, V. A., GILYAZETDINOVA, V. S., AVRAMENKO, P. Ya. et al.

[Abstract] The properties of fine granular graphite formed from the press powder were evaluated as a function of the quality of starting coke. Coal tar pitch was used as the binder. The coke's quality was analyzed in terms of its adsorption capacity for benzene at the relative pressure of 0.25 mmole/g. To help determine the relationship between the characteristics of the starting material and the physical properties of fine

granular graphite, the experiments used were mathematically planned. Data obtained were subjected to regression analysis, from which the optimal composition for the material was established. The best combination of properties in the starting material included a coke adsorption capacity of 0.35-0.45 mmole/g, a binder content of 39-41% and a degree of coke dispersion of 11-12 m^2/g. References 4: all Russian.
[215-7813]

UDC 669.721'74'855:539.375

THE ROLE OF DIFFUSION CREEP DURING SUPERPLASTIC DEFORMATION OF A MAGNESIUM ALLOY

Sverdlovsk FIZIKA METALLOV I METALLOVEDINIYE in Russian Vol 49, No 6, Jul 80 pp 1291-1298 manuscript received 8 Jun 79

VALIYEV, R. Z., KAYBYSHEV, O. A., and SERGEYEV, V. I., Ufa Aviation Institute

[Abstract] The title study was performed using the MA8 alloy (Mg + 1.5% Mn + 0.3% Ce). Experimental data were obtained by two methods: 1) from the diffusion creep (DC) due to the presence of some dispersed structures which act as internal markers; and 2) from the topographic changes in the "banded" zone formed on the surface of samples during their elongation. This mechanism of deformation acts simultaneously with the development of grain boundary shearing, intra-grain slipping and migration of grain boundaries. The contribution of DC to the general deformation is slight: under optimum conditions, i. e., in the superplastic range of the alloy, it represents only a few percent. It therefore is not the controlling mechanism of superplastic deformation. Diffusion creep, under conditions of superplastic flow, acts mainly to reduce stress accumulated during polycrystalline-grain deformation. Figures 1; references 23: 10 Russian, 13 Western.
[178-12027]

UDC 621.762

INVESTIGATION OF THE PROCESS OF HIGHLY POROUS NICKEL STRIP CAPILLARY IMPREGNATION BY LEAD

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 80 pp 90-94 manuscript received 6 Jul 79

TOLSTAYA, M. A., CHIZHIK, S. P., KHOKHLACHEVA, N. M., SHILOVSKAYA, M. Ye., and GRIGOR'YEVA, L. K., Moscow Aviation Technology Institute

[Abstract] It was found that carbonyl powders were more readily impregnated by lead than by electrolytic powders. This was true at all temperatures employed ranging from 340 to 550° C with soaking times of 60 to 180 minutes. The intensity of the capillary process was affected by both material porosity, a function of the production method, and the particle shape and size of the initial nickel powders, which in turn determined the shape and size of the pore channels. In precipitation brazing, two nickel strips with a layer of brazing alloy between them were heated to 350-380° C at a pressure of 2 kgf/mm^2. Here the capillary action and the external pressure promoted filling of the pore channels with lead. It was concluded that the excess of nickel dissolved in the lead melt is transported to the metallic contact at the boundary between the porous and compact nickel, which led to the formation of bridges between the surfaces being joined to produce a strong joint. Figures 3; references 10: 6 Russian, 4 Western.
[133-6368]

UDC 621.762.5:621.763:669.24:620.172

DEPENDENCE OF THE STRENGTH CHARACTERISTICS OF NICKEL FIBERS EXTRUDED FROM POWDER ON THE PROCESS CONDITIONS: REPORT 2

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 80 pp 41-44 manuscript received 4 Jan 80

FEDORCHENKO, I. M., KOSTORNOV, A. G., KIRICHENKO, O. V. and PEREPELKIN, A. V., Institute of Problems of Material Sciences, UkSSR Academy of Sciences

[Abstract] A study of extruded nickel fibers was made to determine the dependence of their strength characteristics on the process conditions. Such nickel fibers 14-42 μm in diameter were tested in tension according to the procedure for textile fibers, with subsequent metallographic examination of fractures and statistical evaluation of the results. Introduction of a scale factor to account for structural anisotropy has reduced the dispersion of strength data, dividing the lot of fibers into three classes: nonporous 14-22 μm in diameter, least porous (0-3%) 22-30 μm in diameter, and porous (3-8%) 30-42 μm in diameter. The tensile strength was found to decrease with larger diameters, to depend on the initial powder condition and content, and to increase with higher sintering temperature. The ultimate strength, at fracture, reached its final level after approximately one hour of sintering: 22-29 kgf/mm^2 for 14-22 μm fibers sintered at 1200° C and 25-35 kgf/mm^2 for 16-42 μm fibers sintered at 1280° C. Longer sintering time did not affect the strength, but a higher sintering temperature resulted in fewer inclusions of strength reducing impurity (Ca, Si, Al) oxides as residual ash after removal of the cellulose binder which had been added earlier for the extrusion process. Figures 2; references 4: all Russian.
[184-2415]

UDC 537.312+621.762.5

EFFECT OF DIFFUSIVE INTERACTION BETWEEN COMPONENTS OF UNLIMITED MUTUAL SOLUBILITY ON THE CONDUCTIVITY OF POWDER COMPOSITES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 80 pp 16-20 manuscript received after revision 26 Jan 80

ZARICHNYAK, Yu. P., Leningrad Institute of Precision Mechanics and Optics

[Abstract] An analytical model is constructed for a mixture of two powders, a matrix in a larger than 50 atom.% amount and an inclusion in a smaller than 50 atom.% amount, to determine the effect of heat treatment at a temperature T over a period of time t after sintering on the resultant

thermal and electric conductivity of the composite. The contact resistance between particles is assumed to be negligible relative to their volume resistances. Considering that a diffusion layer and a concentration field as well as a growth rate are building up in each component during the heat treatment, the mean free path of heat or charge carriers is assumed to be much shorter than the edges of cubic inclusion particles and the edges of cubic elementary matrix lattices. The problem is solved approximately by linearization of the potential field, upon introduction of fictitious infinitesimally thin planes: isopotential ones perpendicular to the flow of thermal flux or electric current and impermeable ones parallel to that flow. Theoretical results based on the solution to the equation of diffusion for metals with f.c.c. crystal lattices are found to agree with experimental data on the electrical conductivity of copper-nickel alloys as a function of the nickel content and as a function of the heat treatment time. It is thus possible, on the basis of this model, to predict the properties and the change in properties of new composite materials. Figures 3; references 7: all Russian.
[184-2415]

UDC 669.295.017:620.182/186

STRUCTURAL CHANGES DURING HEATING OF A COMPLEX TITANIUM ALLOY

Sverdlovsk FIZIKA METALLOV I METALLOVEDINIYE in Russian Vol 49, No 6, Jul 80 pp 1307-1311 manuscript received 22 Jul 70

LYASOTSKIY, I. V., LYASOTSKAYA, V. S., KRASNOYARTSEVA, L. S., and FEOKTISTOVA, Ye. K., Moscow Aviation Technology Institute imeni K. E. Tsiolkovskiy

[Abstract] The title study was performed on the VT22 alloy (4.8% Mo, 4.7% V, 5.2% Al, 1.1% Cr, 1% Fe, balance Ti). Samples of the alloy were quenched in water from 1200° C and examined with an electron microscope to evaluate the fine crystal structure before and after heating to temperatures of 165, 265, 350, and 450° C. The structure appeared to be a heterogeneous beta phase containing small amounts of the omega and alpha configurations. Heating at 265° C resulted in the appearance of an omega phase of uncertain structure. After heating to 350° C, the alpha phase predominated with only traces of the omega form; the latter disappeared completely after heating to 450° C. Figures 2; references 7: 4 Russian, 3 Western.
[178-12027]

UDC 539.375:669.295

FAILURE FLOW AND FRACTURE STRUCTURE IN VT9 ALLOY AFTER HEATING IN THE (ALPHA+BETA)- AND BETA-REGIONS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 80 pp 50-53

PROKHODTSEVA, L. V., SOLONINA, O. P., LYAPICHEVA, N. F. and DROZDOVSKIY, B.A.

[Abstract] The ductile failure and fracture structure of VT9 titanium alloy (6.5% Al, 3.2% Mo, 2.4% Zr and 0.26% Si) were studied after forged rods were given the following heat treatments: 1) annealing for one hour

at 950° C (alpha+beta-region) and 2) annealing for one hour at 1050° C (beta-region). Afterwards both sets of samples were aged for six hours at 530° C. The first heat treatment produced an equiaxial structure and the second a lamellar structure. The equiaxial samples had better tensile strength, elongation and reduction in area values but the lamellar structure is stronger. It is stated only that the failure mechanism is the same for both structures where failure occurs by the nucleation, growth and merging of microcavities. Figures 3; references 6: 2 Russian, 4 Western.
[183-6368]

UDC 669.295'71:621.178.2

THERMAL EMBRITTLEMENT OF TITANIUM-ALUMINUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jul 80 pp 47-50

USHKOV, S. S. and YARMOLOVICH, I. I.

[Abstract] Titanium alloys containing 0.5-8% Al and impurities of Fe, C, Ni and Cr were vacuum-arc double remelted to study thermal embrittlement. After forging the resulting ingots into 15-20-mm rod, the samples were annealed for two hours at temperatures close to the alpha $\rightarrow$(alpha+beta)-transformation, water quenched and aged in an electric furnace. The primary reason for thermal embrittlement of these alloys was the grain-boundary absorption of impurities, specifically iron and nickel. Embrittlement sets in when the alloys are soaked for a long duration at 400-550° C. This embrittlement disappears when annealing is done above 600° C but reappears when the temperature is dropped down to the 400-550° C range. Figures 3; references 9: all Russian.
[183-6368]

UDC 669.295:539.372

RELAXATION OF STRESSES IN STRUCTURAL TITANIUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jul 80 pp 42-46

POVAROV, I. A.

[Abstract] Tests were performed on OT4, VT5-1 and VT22 titanium alloys which simulated the thermal cycles of furnace and zone induction annealing in order to establish the basic principles involved in the relaxation

of residual stresses and optimum annealing parameters. Annealing the above samples of titanium at 600-650, 750-800 and 650-675° C respectively for 0.5-1.0 hours and zone induction annealing weld joints of these materials correspondingly at 650°, 3-10 minutes, 800°, 10 minutes, and 700° C, five minutes, provides almost total removal of residual stresses. The resistance to stress relaxation of the coarse-grain structures at the investigated temperatures is 10-35% higher than for alloys with a fine grain. Resistance to stress relaxation also increases with increased stability and homogeneity of the phase structure. Figures 5; references 8: all Russian.
[183-6368]

DEVELOPMENT OF NEW CLASS OF MATERIALS, AMORPHOUS PRECISION ALLOYS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 29 Jul 80 p 2

[Article by N. Lyakishev, director of the Central Scientific Research Institute of Ferrous Metallurgy, and B. Molotilov, director of the Institute of Precision Alloys of the Central Scientific Research Institute of Ferrous Metallurgy: "Metallic... Glass"]

[Text] A stream of molten metal "shot" through a shaped-section nozzle onto a cold moving surface and, solidifying, wound onto spools as a silvery ribbon. We were in a laboratory at the Central Scientific Research Institute of Ferrous Metallurgy, which is developing methods of transforming metal into "metallic glass." Rolling mills were set up in this laboratory for working molten metal, centrifuges for freezing it onto rotating shafts, and units for high-speed drawing of metal wire from melting pots. Many techniques, but a single principle of obtaining metal with "vitreous" structure -- forcing the molten metal to solidify so rapidly that a crystal lattice does not have time to form.

Ordinary glass, such a common item in our daily lives, is amorphous, in contrast to metal. It contains no crystal lattice -- the atoms of which it is formed are distributed in space not in a rigorously periodic manner but randomly. The atomic structure of glass is closer to the structure of liquids than solids. Experiments have shown that transformation of metal into a "vitreous" state is possible only with ultrafast "freezing" of the metal melt -- at a cooling rate of hundreds of thousands of degrees per second. Another method of "amorphizing" it is ultrafast condensation of a vaporized melt on chilled surfaces.

The structure of "metallic glass" predetermines the unique properties of this substance, which is called an "amorphous precision alloy." The strength of an amorphous alloy is tens of times greater than that of a conventional crystalline alloy, since development of plastic deformation in an amorphous alloy is made difficult by the absence of the atomic defects which are typical of crystalline bodies. Amorphous alloys, due to irregularity of the atomic structure and a high concentration of "chemical" defects, possess electric resistance which is several times greater than that of crystalline materials.

The abnormally high corrosion resistance of amorphous materials is also explainable: they lack grain boundaries -- points from which corrosion normally begins to develop in crystalline materials. We should add to this "set" of unique features excellent magnetic properties, low energy losses during alternating magnetization, and superconductivity. These and a number of other characteristics are especially important for utilization of strips of amorphous alloys in transformers, relays, switches, and magnetic screens. In these applications they are simply a godsend.

Will amorphous alloys replace metals traditionally employed in industry? This is not the goal, for in many cases the properties of conventional crystalline alloys fully satisfy the requirements of instrument engineers. However, for instruments operating in complex conditions involving low temperatures, high mechanical loads, and aggressive corrosive environments, amorphous precision alloys prove to be substantially more "adapted" than their crystalline cousins.

Coils of amorphous strip 30 microns thick, obtained by ultrafast quenching of metal melts, are a finished metallurgical product suitable for fabrication of items in the instrument engineering industry.

Let us recall how extremely thin metal strip of conventional alloys is obtained by "traditional" metallurgical methods. A great deal of labor is expended to transform a metal ingot into strip. First it is rolled on a roughing mill, heated and run through a series of special rolls; the metal is then pickled and subsequently run through numerous rolling-mill passes, alternating with heat treatment and finishing operations. Final rolling reduction of the strip to thicknesses of 50-30 microns is performed on special multihigh mills, after which it is cut into strips of the required width and wound into coils. This is the "classic" metallurgical biography of the strip. The entire "conversion" of the alloy, as metallurgists say -- from charging to finished strip -- runs several weeks under conditions of continuous production at a metallurgical plant.

The process of obtaining amorphous strip several kilometers in length takes only a few minutes and consists of a single operation -- forming in the process of ultrafast quenching of the melt.

The history of science and technology contains many examples where the discovery of new materials with new properties led to revolutions in scientific and technological advance. Semiconductor materials, for example, led to the birth of modern microelectronics, and superconducting materials -- to the development of cryogenic superelectrotechnology. This new class of materials -- amorphous precision alloys -- is still at the cradle stage. But we can already state that their unique advantages will make it possible to accomplish a new step forward in the development of instrument engineering.

Employment of fundamentally new materials requires thorough preparation: new material is always a departure from the customary and requires non-standard handling and processing methods. Practical utilization of amorphous precision alloys will also cause certain difficulties at first. Machining of such alloys, for example, is difficult because of their high strength and hardness, requiring special tools. These difficulties are surmountable, however, and the unique physical properties will fully compensate for all expenditures on preparation for and practical adoption of new technology.
[181-3024]

3024
CSO: 1842

THE USE OF THE AUTOELECTRONIC EMISSION EFFECT FOR REFINING METALS

Minsk IZOBRETATEL' I RATSIONALIZATOR in Russian No 6, 1980 pp 10-11

[Article by L. Rodzinskiy, engineer, "Weight loss of machines: an actual result of the utilization of a new method of "electronic cleaning" of a melted metal which is extremely original in art and validated in practice"]

> The problem of improving efficiency of production in general and the quality of goods produced is solved in various ways. Engaged in improving the quality of casting alloys, scientists of the Ural Scientific Center of the USSR Academy of Sciences brought to bear in metallurgy the known effect of autoelectronic emission, which is used in radio engineering and electronics. Based on the this effect the method [author certificates No 436094 and No 449937] makes it possible to remotely control harmful admixtures. It is possible to significantly reduce weak spots in parts, which are cast from alloys purified by this new method, which will provide the national economy with a savings of millions of tons of steel, pig iron and ferrous metals, which precipitate out as dead weight in metal founding.

[Text] The universally famous building of the famous Smol'niy in Leningrad was constructed at the beginning of the 19th century. The roof of the palace, which is faced with sheets of rolled iron, did not require painting and repair until it was pierced by fragments of shells and bombs in World War II. The secret of the corrosion resistance and strength of the metal is not in the alloying additives, but in the high purity of the iron smelted by masters of the Kirsinsk Metallurgical Plant (the settlement Kirs in Kirovskaya Oblast). In the ovens of the patriarch of Russian Metallurgical plants the iron ore was melted over charcoal and the iron obtained a rare purity, and became exceedingly strong and corrosion resistant.

Charcoal no longer suffices for mass production of metal. Smelted metals are subjected to special cleaning-refining, in which process impurities and gas inclusions are removed. Doctor of Technical Sciences B. M. Lepinskikh and his colleagues A. V. Kaybichev and A. A. Belousov are engaged in improving methods of refining casting alloys at the Laboratory of Physical Chemistry of Metallurgical Alloys of the Institute of Metallurgy of the USSR Academy of Sciences Ural Scientific Center.

The theoretical premise of the Ural scientists was quite unusual: they represented the boundary between the melt of a liquid metal and the gaseous environment by a separation surface of the simplest electronic tube--a diode. From here it was only one step to the adjacent concept of autoelectronic emission. That is a name given to emission of electrons by a surface of a metal as a result of the action of an external electric field, which promotes their directional migration. Such directional migration was first encountered in the middle of the previous century by the English physicist Grove, in whose tests metal from the surface of the cathode transferred to the walls of a tube during a gas discharge. The shape of the cathode changed and the tube walls were covered with a metallic coating.

The evolution of technology placed this discovery in the service of radio engineering and electronics, endowing humanity with radio receivers, television sets and other electronic technology. Now metallurgists are looking to autoelectronic emission. By utilizing its known directivity of migration, they secured its selectivity, the possibility of influencing the migration of precisely those substances which it was necessary to eliminate or with which it was necessary to saturate a melt. To do this the Sverdlov scientists even more sharply identified the difference in electrical potentials between the melted metals and the gas medium, attaching direct current electrodes of different charge to them. At the same time they changed the composition of the gas medium, injecting neutral gas into it, for example helium, or slightly active ones such as nitrogen. In some experiments they used a strong vacuum as the gas medium. When there was positive polarity (plus--is the gas medium) and a neutral helium atmosphere they removed admixtures (carbon, silicon, sulfur, phosphorous), bringing the melts to chemically pure substances. When there was negative polarity they saturated the melts with the necessary admixture, for example nitrogen. The initial conditions were varied in every possible combination for each of the numerous kinds of melts investigated, until the accumulated statistics ceased to reflect reliably reproducible characteristics.

One result of the work was the method of controllable field evaporation which has been defended by several authors, that is the active removal of specific components of a melt which has been saturated by gases and foreign admixtures and which has been placed in an electric field. By utilizing the new method it is possible, for example, to degasify a melt or to saturate it with a gas, let us say nitrogen, and to remove admixtures

and impurities from it, which are inevitable due to the introduction of reducing agents into the melt. Controlling the course of the process is not complicated, because the end result is easily predicted and is determined by a specific value and polarity of a potential. The strength and service life of parts made from such a metal are significantly greater. Thus, by saturating a melt of steel with nitrogen a cementite structure is obtained rather than a perlite one, and the hardness of the material following tempering is increased by twenty units on the Rockwell scale. An additional advantage of the method is that chemically pure ferrous and nonferrous metals, alloys and even semiconductor materials can be made on ordinary equipment, quickly and with minimal wastes.

But will everything be so easy under industrial conditions as it was in the experimental installation? A great number of ideas, which were beautifully illustrated in laboratories ingloriously disappeared when they encountered the hard reality of the plant shop. And the director of the casting shop of the industrial association "Turbomotorny zavod im. K. Ye. Voroshilov", a confederate and co-author with the scientist V. A. P'yankov, suggested that they conduct an industrial verification of the method directly in the shop.

Under the fault-finding glances of skeptics and simply curious onlookers they loaded the cupola with pigs with the most ordinary cast iron--they gathered it indiscriminately, without interruption. The metal was melted and poured off into a receptacle, where the scientists took over. After fussing over it with instruments and gas balloons for awhile, they offered a casting that the factory hands had never before seen even in their best melts.

Unfortunately, now one can only imagine what was poured off from the surplus of harmful admixtures, pockets and gas bubbles of the pig iron. The components of the metal of that melting which took place several years ago, disappeared from the plant without a trace. But the cast iron purified by the scientists is still remembered in the shop. For a high grade metal is the most important source of material savings. If the strength is increased, then one can decrease consumption by reducing the safety factor margins. Currently these margins, legalized by all kinds of design standards and by GOST guarantee reliability in the exploitation of the most heavily loaded parts. But given the magnitude of the All-Union Machine Building industry the current safety margins result in a waste of millions of tons of metal. This new method for processing casting melts makes it possible to put these millions of tons to good use. Once metal becomes stronger it becomes possible to make many machines lighter without losing a single technical characteristic, merely by reducing the thicknesses and dimensions of parts. An additional advantage of the new method is that it is possible to produce high grade metal even at small nonspecialized enterprises, especially where the stumbling block of a significant expenditure of electric power does not exist--the single disadvantage of electronic refining.

It would seem that the work of the Sverdlov metallurgists would be greeted with enthusiasm by industry. But it has not been taken up. In order to implement the new method it is necessary to introduce certain adjustments to the complex technology and to acquire additional equipment and instruments. But even at the "Turbomotornyy zavod" technological department, where the industrial applicability of the innovation was demonstrated, this has not been done.

However, additional equipment and a change in the technological process are secondary reasons. The real reason is something else. Industry has not assimilated this and many other inventions, which are intended to economize on materials, because it is not advantageous to industry to economize. Output, for example, of the same metallic casting, is planned according to the notorious gross output--the more tons the better. This is absolutely correct in principle, but when appeals for economy are unsupported by economic measures nothing will be done.

Precisely such measures have been introduced by the latest decrees of the CPSU Central Committee and the Soviet government concerning problems of the economy and planning. Now, when the work of an enterprise will be evaluated not by gross output calculations, but according to the specific labor contribution of a team, by the increase of net production and on fulfillment of customers' orders, the objective reasons preventing the introduction of many inventions, especially those which yield an economy of materials, must disappear. When an improvement in metal quality becomes the principal means of its conservation and of the further growth of metallurgy in general, electronic refining should finally emerge from the laboratory into industry.

[168-9424]

9424
CSO: 1842

UDC 621.762.274

ELECTROLYTIC POWDERS OF Fe AND FeCo ALLOYS FOR PERMANENT MAGNETS

Kiev KHIMICHESKAYA TEKHNOLOGIYA in Russian No 3, 1980 submitted 12 Mar 78 signed to press 7 May 80 pp 8-11

SVETS, T. M.

[Abstract] Alternatives to the production of highly dispersed Fe and FeCo alloy powders on the basis of reduction of these metals in a hydrogen environment were discussed with emphasis on the production of them by electrodeposition in a 2-layer bath on a vertically rotating disk cathode. The discussion includes description of the dependence of the current efficiency of Fe and FeCo powders on the electrolyte concentration, the shape and degree of dispersion of particles and their oxidizability and the effect of temperature of the electrolyte on the current efficiency of the powders and the dependence of the efficiency of the powders on the cathode current density. It was found that the magnetic characteristics of the powders are determined completely by electrochemical factors that can be controlled in the production process.
[211-2791]

UDC 621.357.7

CURRENT EFFICIENCY OF ELECTROCHEMICALLY TREATED NICKEL-CHROME ALLOYS

Moscow ZASHCHITA METALLOV in Russian Vol 16, No 4, 1980 pp 471-474 manuscript received 9 Apr 78; edited 7 May 79

AMIRKHANOVA, N. A., SOLODOVNIKOV, S. F., TATARINOVA, O. M. and RAFIKOVA, L. G., Ufa Aviation Institute

[Abstract] The current efficiency of the anodic dissolution of a series of deformable dispersion-hardenable nickel-chrome alloys with varying content of the γ' phase (EI-826, EI-929, EP-220) in electrolytes having

the same electrical conductivity (2.5 n. Nacl; 3.5 n. $NaNO_3$) was investigated. Following polarization of the alloys, the content of Ni and Cr was photocolorimetrically determined. The composition of the surface layer of the alloy before and after polarization was investigated with the aid of a Cameca microanalyzer. The components of the EI826 alloy, which contains the least amount of the γ' phase, were found to dissolve most uniformly, and current efficiency in 2.5 n. NaCl was found to be greater. The surface film forming on the anodes in $NaNO_3$ solutions covers the entire surface, while in NaCl solutions it is discontinuous, apparently because, during ionization of nickel-chrome alloys in NaCl solutions the adsorption of Cl^- ions impedes the formation of a continuous passive Cr_2O_3 film. The current efficiency of the investigated nickel-chrome alloys, whose Cr content ranges from 12 to 18%, does not exceed 100%. In general, during the anodic dissolution of these complex nickel-chrome alloys, the ionization of components proceeds in direct proportion to their percentile content. In the course of the anodic polarization by means of high current densities (10-20 a/cm^2) the γ' phase and the carbidic components get dissolved, since their dissolution potentials are reached. In NaCl electrolytes during ionization the Cr in these alloys dissolves both in tri- and hexavalent forms. Figures 1; references 10: all Russian.
[174-1386]

UDC 539.2:530.145

EFFECT OF CRYSTAL POTENTIAL ANISOTROPY ON BAND STRUCTURE OF TITANIUM AND NICKEL

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 49, No 5, 1980 pp 1109-1113 manuscript received 16 Mar 79; edited 8 Jun 79

BOLETSKAYA, T. K., YEGORUSHKIN, V. Ye. and FADIN, V. P., Siberian Physico-Technical Institute imeni V. D. Kuznetsov

[Abstract] Numerical algorithms for computing the crystal potential generated by the anisotropic charge distribution within the Slater sphere are presented. Anisotropic addenda to the potentials of the transition metals Ti and Ni are found. Non-MT [Muffin-Tim] corrections of Ti and Ni spectra are computed from the standpoint of the KKR [Korringa-Kohn-Rostoker] method. The derived distribution of the multipole moment of the crystal electron density shows that the anisotropic addenda are maximal in the nearest-neighbor orientations: [111] for BCC lattice and [110] for FCC lattice. The tabulated order of these addenda indicates that the metal properties not associated with fine detail of the Fermi surface, such as x-ray and optical spectra, can be computed on the basis of the MT spectrum. The KKR method is not as convenient as the APR [Augmented Plane Wave] method when it comes to performing anisotropy calculations. Figures 3; references 15: 3 Russian, 12 Western.
[176-1386]

UDC 535.211;620.193.1

ON THE QUESTION OF THE SPECIFIC ENERGY OF DISINTEGRATION OF METALS AND ALLOYS

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, 1980
pp 16-19

VERKHOTUROV, A. D., KOVALENKO, V. S., and DYATEL, V. P., Kiev

[Abstract] An investigation was made of the influence of the nature of materials and methods of their processing on the specific energy of disintegration (SED) of metals and hard alloys undergoing multiple-impulse laser treatment under conditions of quasi-stationary evaporation. A formula was proposed in accordance with which the SED of refractory metals and alloys was estimated, and it was noted that the highest values of SED occur in hard alloys of the TK type. It was also shown that in the case of multiple-impulse laser treatment the SED depends on the number of impulses and is stabilized at $n \geq 3$-5. No agreement was noted between experimental and rated values of SED, especially as regards refractory metals of group VI and hard alloys. The optimum routes for determination of the stable values of SED were suggested. Figures 4; references 5: all Russian.
[150-1015]

UDC 621.3.038.8

ON THE STRESSED STATE OF SURFACE LAYERS OF LASER-STRENGTHENED MATERIALS

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, 1980
pp 34-39

KOVALENKO, V. S., BEZYKORNOV, A. I., and GOLOVKO, L. F., Kiev

[Abstract] An experimental study was made of the influence of regimes of laser irradiation on the magnitude, sign and type of the distribution of residual stresses in the surface layers of steels strengthened by laser emission. Investigated were: St45 annealed steel and U8A steel in the annealed and hardened states, whose 3 x 7 x 50 micron samples were irradiated by a "Kvant-16" unit with various power densities of radiation over the range $2 \cdot 10^4$-$2 \cdot 10^5$ w/cm^2. Radiant energy was monitored by an IKT1M calorimetric gage and maintained constant (36 joules). The analysis of distribution of residual stresses in the surface layer of steel St45 strengthened by laser emission at various intensities showed that these stresses depend on the power density of laser radiation. At low power densities fairly large tensile stresses developed in the surface layer, and with the increase of power density a gradual decrease of tensile

residual stresses was observed. At moderate power densities a relative depthwise stabilization of stress values was noted, and with a further increase of radiation intensity residual stresses changed their sign and become compressive, whereas in deeper layers the growth of tensile stresses continued more intensively. The nature of distribution of residual stresses in U8A steel essentially didn't differ from that in the St45 steel, except for the deeper layers, where tensile stresses were somewhat more intensive. It is concluded that these changes are determined by power densities of laser emission and that by controlling them one can create controllable residual stresses in the surface layers of laser-strengthened materials. Figures 4; references 4: all Russian.
[150-1015]

UDC 539.32:539.67

INVESTIGATION OF YOUNG'S MODULUS AND MODULUS OF INTERNAL FRICTION WITHIN THE 20°C-MELTING POINT TEMPERATURE RANGE INCLUSIVELY

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 49, No 5, 1980 pp 1075-1080 manuscript received 18 Jan 79; edited 8 May 79

DRAPKIN, B. M., BIRFEL'D, A. A., KONONENKO, V. K., and KALYUKIN, Yu. N., Rybinsk Aviation Technology Institute

[Abstract] A method serving to determine Young's modulus E and modulus of internal friction δ in solids was used. The method is based on placing a specimen of the investigated material in a casing of another material having a much higher melting point. In the cases investigated the casing used was an aluminum tube filled with Sn, Bi, Cd, Pb. The possibility of finding the E of the investigated material as a function of known characteristics of tube material and of the specimen material is demonstrated. It is shown that the E for Pb somewhat increases in the neighborhood of the melting point (m.p.) whereas for the other metals a marked decrease in E is observed in the neighborhood of their m.p. The curves of the temperature dependence of δ for these metals display two peaks: a low-temperature peak associated with grain boundaries, and a high-temperature peak associated with the anomalous behavior of materials in the vicinity of the phase-transition temperature. Figures 4; references 18: 13 Russian, 5 Western.
[176-1386]

UDC 669.15'24'25:538.2

ASPECTS OF THE MAGNETIC PROPERTIES OF Fe-Co-Ni PERMINVAR ALLOYS IN THE MAGNETIC ISOTROPY REGION

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 49, No 5, May 80 pp 994-1001 manuscript received 7 May 79

PETRENKO, E. D., PUZEY, I. M., BORODKINA, M. M., SAVVIN, A. N. and OREKHOVA, T. S., Institute of Precision Alloys, Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] The magnetic properties and shape of the hysteresis loop of perminvar Fe-Co-Ni alloys with 40% Ni were investigated on 10 specimens following their longitudinal and transverse thermomechanical treatment in the region of magnetic crystalline anisotropy. Analysis of hysteresis loop shape following transverse thermomechanical treatment was used to pinpoint the boundary of transition from positive to negative anisotropy. It is shown that after annealing in a transverse magnetic field the cubic texture affects the hysteresis loop shape of alloys with a positive anisotropy constant. To assure a highly linear hysteresis loop (necessary for inductance coils), it is best to select those alloys located in the immediate neighborhood of the anisotropy reversal boundary, since these display the highest level of static magnetic properties and the highest unit magnetization reversal loss at frequencies of 400 and 1000 Hz. Figures 5; references 5: all Russian.
[176-1386]

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